REPORT

ON THE

EXPERIMENTAL CULTURE OF THE OPIUM POPPY

WITH

OBSERVATIONS ON ITS DRUG-YIELDING PROPERTIES,

AND THE MORE PREVALENT AND SERIOUS FORMS OF DISEASE AND INJURY TO WHICH THE PLANT IS SUBJECT

FOR

THE SEASON ENDING 15TH APRIL 1874.

BY

JOHN SCOTT, Esq.,

On Special Duty, Opium Department.

Calcutta:

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Harry Soane. 1888.

No. 160, dated Deegah, the 10th June 1874.

From—JOHN SCOTT, Esq., On special duty, Opium Department,
To—W. H. GRIMLEY, Esq., Offg. Secretary to the Board of Revenue, L.P.

I HAVE the honor to submit my report (for the season ending April 15th) on the experimental culture of the opium poppy, with observations on its drug-yielding properties, as also the more prevalent and serious forms of disease and injury to which the plant is subject.

2. The experimental gardens are at Meetapore in the vicinity of Bankipore, and at Deegah, near Dinapore; the former comprising an area of 12 beeghas* and 18 cottahs; the latter 39 beeghas 19 cottahs; of which 28 beeghas 5 cottahs are inside the old prison walls, and 11 beeghas 14 cottahs outside. The Meetapore lands were tilled during the hot and early part of the rainy season, and in part sown with the seeds of the plants marginally noted. This I had done with a view to their being ploughed in on attaining a certain maturity (viz., immediately prior to, or while in blossom) as a green manure. In the appendix to the report on the Meetapore gardens, page 13, table 1, I have given the technical and native names of each of the plants, the area sown in square feet, the quantity of seed used, and the periods of sowing and ploughing into the soil. It may be as well, however, to state here that the sowings extended from the beginning of May until the end of July, while the ploughings in of the crops commenced about the end of August, and were continued until the middle of September. A few of the species experimented with utterly failed while young, from an excess of rain in *July*, others—especially Indigo—suffered, on the other hand, from a lack of the latter (the *temperature* being *unusually dry* and *hot throughout June*); while, again, on other portions the soil had been so thoroughly exhausted, that though the crops survived, they never acquired any vigour, and were thus of no manurial value.

* This is the opium beegha of 27,225 square feet.

Abelmoschus esculentus.
Crotolaria juncea.
Indigofera tinctoria.
Cajanus indicus.
Dolichos sp.
Helianthus annuus.
Sesamum indicum.
Solanum esculentum.
Tiaridium indicum.
Amaranthus Gangeticus.
Rumex vesicarius,
Panicum miliaceum,
Penicillaria spicata.
Zea mays.

3. The above selection of plants was the best for the above purpose of which seeds were available for *rainy season culture.* Many plants of a much higher manurial value could be had for cold weather cropping; *e.g.* Sursho and Rai, including various species of *Sinapis*, "Joorhooriya," *Cleome pentaphylla*, and *C. icosandra*, Juro-shelkanta, *Argemone Mexicana* (care being taken to have *this* cut and ploughed in with the appearance of the earliest flower, to prevent its shedding mature seeds, and thus establishing itself on the lands), the *Boro-joon*, *Pan-muhoree*, *Bunjoon*, *Soolpha*, and *Dhunya*, all umbelliferous plants of the genera *thychotis*, *Fœniculum Cnidium*, *Anéthum*, and *Coriandrum.* Of leguminous plants, I may specially mention the burocheena, *Vicia sativa;* chola or chama. *Cicer arietinum*, the *gram* of Europeans; the Musoors and Khesaree of the natives, species of *Ervum* and *Lathyrus.* There are also many common, indeed weedy plants of waste lands, road sides, &c., of the Purslane, the Madder, the Composite, the Borage, the Labiate, and other natural orders which afford members well adapted for application as green manures. As incurring, however, the loss of an opium crop, I have made no trial of any of these cold season annuals.

4. The high manurial value of indigo-water is well-known; and where available, is generally applied to the soil; but less, if at all known, is the *Sonai* or *Jute-water*, tons and tons of which is lost in the jheels and tanks in which the plants are steeped. I could only make a very limited trial of Sonai-water, but this sufficiently showed its high manurial value, as the portion thus treated yielded indeed a very fair crop of poppy, whereas on the adjoining and untreated portion, the plant barely existed. I shall give the details of this experiment in a subsequent paragraph.

5. The aquatic vegetation of our jheels, tanks, and other stagnant water also affords in many cases a highly energetic manure. Water impregnated with the decomposed janjh, jhanjhi or jala of the natives (which include species of such genera as *Ceratophyllum*, *Hydrilla*, *Vallisneria*, *Lemna*, *Pistia*, also called taka pona, and *Chara*) the soosni-shak, (*Marsillea quadrifolia*), the pana (*Azolla pinnata*), the oolki-pona (*Salvinia verticillata*), and the indoor-kanee pana, (*Salvinia cucullata*), may also be applied with great advantage to the soil. I notice these specially here as they are so generally neglected and lost even in districts where other manures are scarcely at all to be had. In one of my experimental plots at Deegah, poppy watered some four or five times with tank-water strongly impregnated with the decomposing leaves and stems of *Hydrilla verticillata*, *Ceratophyllum verticillatum*, and species of *Chara* grew with much vigour, presenting a marked contrast with the unmanured plants in the adjoining plot, as will be shown by the details of the experiment in the sequel.

6. The manurial value of some of these plants is well known in Europe, and considering their abundance in all moist inter-tropical regions (where a paucity of manure is so frequently one of the most serious of the agriculturist's difficulties) I have thought it worth while adding in this place the following extract on *chara*, as a manure plant, from an excellent paper on green manures by Dr. Sprengel, and of which there is a translation from the German in the *Gardener's Chronicle* for December 1842:—"Chara.—The species of this genus are all annual, and grow only in stagnant waters rich in saline matter, whence we may conclude that such substances enter abundantly into their composition. Chemical analysis confirms this, as 1,000lb of green chara (*C. vulgaris*) consists of 158lb of carbonate of lime mostly deposited on the plant itself, 8lb of chlorine, and 12lb of soda. They, moreover, contain a large quantity of nitrogen, in fact, as much as 3·9 in 1,000lb of the green plant. No doubt they also contain much sulphur and an abundance of phosphorus, for in their speedy decomposition much sulphureted and phosphoreted hydrogen are developed. Although growing in water, they contain but a comparatively small amount of that fluid—in 1,000lb of the green plant 596lb of water—all of which leads to the conclusion, that even in small quantities, they must be a powerful manure. In fact, experience has already shown that if used too copiously, they produce an over luxuriant growth. In collecting the chara for manure, it is drawn out of the water by hooks used by a person standing upright in a boat. It is then collected on shore, either in large heaps, where it is left for some time to rot, or conveyed at once to the land, over which it is thinly spread and at once ploughed in. The latter plan is the better; because when chara rots in heaps it loses much gaseous matter, in the form of ammonia, sulphureted and carbonated hydrogen, &c. The quantity of chara required for an acre of land is from 9,000 to 10,000lb of the green plant, which is considered equal to a heavy manuring with ordinary farm-yard refuse. On lands thus treated crops will grow well for the next three or four years, a circumstance easily explained, because 5,000lb of the green herbage convey to the soil 800lb of carbonate of lime and 20lb of nitrogen. *Hornwort*, *Ceratophyllum*-like chara, is encrusted with carbonate of lime, and acts more powerfully. Duckweed deserves less attention."

7. The Meetapore lands were ploughed over several times after the green manurial applications, and prior to the sowing of the seed various other manures were in many cases applied, details of which will be given under the respective plots. As a guide to those allotments, I append a plan of the garden, in which each plot is numbered, and the area given in square feet.

8. The preparation of the Deegah lands was a work of difficulty and considerable expense. As will be seen from the appended plan, the larger portion of the land is enclosed by the old jail walls ($28\frac{1}{4}$ beeghas of the 40 beeghas I had under cultivation), and when made over to me was studded with the prisoner's huts and other buildings, all in a ruinous condition. The labor for pulling down the huts and clearing the material cost Rs. 735; while the sale of the old bricks, tiles, and bamboo frame-work of the buildings (which

were nearly all rotten) realized only Rs. 364-12. The bullah posts of the old huts, however, have been very serviceable as well-posts: forming substantial supports for the bamboos and buckets by which water is raised for irrigation. I have in all 60 of these posts in the Deegah lands and 28 at Meetapore. I could not have bought them on an average under Rs. 5 per post, which would thus have necessitated an additional outlay of Rs. 440. The remaining portion of the posts for which I have no use have been made over to the Department of Public Works. I should state here that the cook-rooms and hospital only had brick-walls and tiled-roofs, while the other huts had mud or sun-dried brickwalls, with roofs of bamboo frame-work, and as none of them had either been renewed or repaired for some seven or eight years the dilapidated condition in which all must have fallen will be understood Again, in filling up old excavations, levelling lands, collecting old bricks, tiles, &c., an outlay was incurred of Rs. 240-6, while the half-trenching of the land (the surface soil of which to a depth of 12 inches was a dense net-work of doob-grass roots interspersed with tufts of the common kash-grass), in the first instance cost Rs. 270, or upwards of Rs. 10 per beegha. The pulverizing of the land and the clearing of the grass roots was tedious and hard work: rendered increasingly so by the unusual dryness of the season: the dry clods being in fact almost as hard as stones, giving quite a metallic ring when struck with a hammer, and had all to be broke down with mallets. In the anticipation of a fall of rain in August or September (which would have much facilitated the operations) I half-trenched the whole of the lands, but the little rain that we had during these months had no appreciable effect, and I had much difficulty in getting all even roughly broken down, far less into that highly pulverized condition so necessary for the first stages of development of the poppy plant. One and all of the native cultivators were indeed strongly of opinion that poppy would never succeed on such coarsely prepared soil, and strongly advised me to abandon the idea of poppy, and plant all up with potatoes, onions, and the like. This I of course would not listen to, and I soon afterwards satisfied myself that but for an insufficient supply of water, I should have had a vigorous and uniform crop.

9. The Deegah lands outside the wall formed a portion of the jail garden, and though they had been little under cultivation, and never manured since the jail was broken up, the native cultivators had all a high opinion of their fertility. I was doubtful of this, as, unlike the lands inside the jail, they had been overrun with one of the most impoverishing and difficult to eradicate of all the native grasses; this is the Moota or Moosta,—properly a sedge, the *Cyperus hexastachyus*. It has an extensively spreading and deeply penetrating rhizome, giving off numerous tubers, each of which again gives off an ascending bud and form other centres of extension. Roxburgh well remarks that "it is by far the most troublesome weed we have in our gardens; there is no extirpating it, as every little bit of the root grows readily." In trenching over the land, I had the *moota* tubers very carefully picked out, and so also in the diggings preparatory to sowing. In spite of all this, however, it nearly everywhere supplanted the poppy, and even after re-weeding and re-sowing, the crop was thin and starved, as I shall show in the detailed results.

10. Besides the above noted preliminary difficulties in breaking in the lands (and which of course have not to be repeated), I had another no less serious one in arranging for their irrigation. On the Deegah lands I had but *one* well, and on those at Meetapore *none*. At Deegah I had to sink 26 wells of a diameter of from five to six feet, the sub-soil being of a very tenacious character, and passing at a depth of from 40 to 50 feet (when I reached my water-supply) into a layer of *kunkar*; two only of these wells fell in. Two others being opened in their place, I sunk in all 28 wells there. At Meetapore I commenced sinking wells five feet in diameter: but this I had soon to abandon, as at a depth of about 20 feet I had to penetrate a layer of waterless sand which almost invariably bulged out as it was passed, causing great slips of the upper layers and quite closing up the well. I had several mishaps of this sort, and had thus to open wells of from three to four feet in diameter; in

all 26. These stood fairly well, even though from 30 to 50 feet in depth; requiring, however, like those of larger diameter, to be pinned round with firm ropes of a coarse native grass, locally known as *inkur*, a species of Saccharum. The well-sinking, cost and preparation of the material in the two gardens, has thus been a considerable item in the outlay; amounting to upwards of Rs. 700. With these preliminary remarks I shall now give a history of each plot; the kind and quantity of manure applied; the condition of the crop, and the produce of drug and seeds. I shall begin with the Meetapore garden, taking up the plots consecutively, as shown in the appended plan of the grounds.

Section 1.—Meetapore Garden.

1. This plot consists of about 19¼ cottahs. In August and the early part of September it had a liberal application of fæces and urine from the adjoining jail; these were trenched in to a depth of 18 inches. During October it was frequently ploughed over, and poppy-seed sowing was commenced on the 8th of November. The seed (as in the case of many of the other plots, from an insufficient supply of water) germinated badly, and the partial re-sowings had also but indifferent success, though the young plants in all cases were very healthy. Average specimens, uprooted towards the close of January, were 19 inches in height; leaves, from 10 to 13 inches long by 4 to 7 inches broad; the tap-root, (4 to 5 inches), branching into several main divisions, and all very fibry. The weight of six fresh plants was 27½ oz.; while in the air-dry state they only weighed 6½ oz. I remarked on the general vigour of the plants—'the stem stout, and well clad with leaves of a deep glaucous green.' The first flower expanded in the end of January, and the extraction of the drug was commenced on the 12th of February, and continued until the 28th of March; irrigation was successfully continued during the latter operation. I say *successfully*, because it is a practice strongly opposed by the *local* cultivators, who altogether discontinue watering while collecting drug, repeating it once only after the plants will yield no more drug, to enable them, as they say, to mature a full quantity of seed. Though this practice may suit their lands in very moist seasons, it is, as might be expected, very objectionable in such dry seasons as the past. I explained this to several of the cultivators adjoining my gardens, but they would insist that the plants if then watered would yield no more opium. I showed them that the *regularly watered plants* were yielding more drug than the *unwatered* in my garden, but this they attributed to the different kind of manures I had applied, persistingly holding by their old practice, plain though the result was that the watered plants continued to yield drug from 10 to 15, and even 20 days after those unwatered were dry and mature. The yield of drug was 6 seers and 13 chittacks.—I notice here only the quantity of drug, as all the collections from the several plots have been submitted to the Principal Assistant to the Behar Opium Agent for analysis and report. I will only add that in every case it was of good quality, and always exceeded, sometimes very considerably, the standard consistence.—The seed produce was in all 90 seers 7 chittacks, of which 10 seers only were the produce of capsules lanced five times and upwards.

2. The area of this plot is somewhat over 10 cottahs. On the 15th of October, after repeated ploughings, it had an application of 3 maunds of the Superphosphate of lime, with 4 maunds of powdered charcoal. This was also ploughed in and the seed sown on the 18th of November. The plant germinated very indifferently, and was of very slow growth; this was the case until well on in January—so slow was the above manure in producing any well-marked effect. Towards the close of January, when taking up specimens for weighing, I remarked—'plants of slow growth as compared with others on adjoining plots—stems slender, very sparingly branched; leaves of a palish green, altogether unsatisfactory, but probably largely due to my being unable to apply the manure to the land some months earlier; the effects may be more marked on next season's crop.' It was also but a poor sample of *superphosphate*, though certainly an inexpensive one, costing only Rs. 2 per maund. Average

specimens (I should mention here that in this, as in succeeding plots, the sample specimens were in all cases taken up when about *two months old*, a period at which all the manures might be expected to produce more or less marked effects) were 12 inches high; leaves, 7 to 9 inches long by 2 to 4 inches broad; the main tap-root 6 to 8 inches, slightly branched, but bearing numerous wide-spreading fibres. Six fresh plants weighed 4½oz., while in the air-dry state they were reduced to 3½drs. The opium weighed 1 seer 9 chittacks, and the total weight of seed, 38 seers, of which 6 seers only were from the more copious drug-producing capsules.

3. This plot is of the same area as the preceding, and on the 15th of October had an application of 2 maunds ammoniac sulphate mixed with 4 maunds of powdered charcoal.—In this, as in other cases, I may once for all explain that the charcoal was used as well with the view of distributing more equally the special manure, as also from its powers of absorbing and storing ammonia for gradual utilization by the crop. Again, under the impression that ammoniacal vapours were highly conducive to the development of the poppy blight, I thought to check it considerably by thus rendering ammonia and its volatile compounds only very slowly available to the plant. From observations and experiments, however, which I shall record in the sequel, I am convinced that it is rather to an *excess of carbonic acid than ammonia* in the plant or its environings that the sudden appearance and rapid extension of the poppy mould is due.—The above manurial application being well mixed with the surface soil, the poppy-seeds were sown on the 18th of November; germination free and rapid, and my remarks in taking up the samples are—'plants of vigorous and free growth; stems stout, with full and copious foliage of a deep glaucous green.' Average specimens, 24 inches high; leaves, 8 to 12 inches long by 4 to 7 inches broad; tap-root, 4 to 6 inches long, freely branched, and very fibry. Six fresh plants weighed 28oz., and in the air-dry state 5½oz. Opium weighed 5 seers 3 chittacks; seed, 67 seers, of which 7½ seers only were the produce of the first-class capsules.

4. This is also a 10-cottah plot, and had for a manurial application, on the 16th October, 4 maunds Comptons guano mixed with 4 maunds of charcoal. Seeds were sown on the 12th of November; the germination was very tardy, but this was due to the lands requiring water prior to the germination of the seed, which I now know retards greatly the latter process and in clayey lands will indeed altogether arrest it. Partial re-sowings were thus required. The young plants were of slow growth, and of rather a palish color. Subsequently—about the beginning of January—they acquired more vigour; and in collecting the samples I observed 'plants very healthy, with stout, but slightly ramose stalks, and copious foliage of a pale glaucous green; still less forward in growth than those of the adjoining plots 3 and 5.' Height of plant, 14 inches; leaves, 7 to 10 inches long by 3½ to 5 inches broad; main-root, 4 to 6 inches; slightly ramose, and throughout fibry. Weight of six fresh plants, 10½oz., air-dried, 2¾oz. Opium weighed 1 seer 13 chittacks; seeds 43 seers 8 chittacks, of which 3 seers only were the produce of the good capsules.

5. Another 10-cottah plot. This had on the 16th October an application of 2 maunds guano phosphate in 4 maunds of powdered charcoal. Seeds sown on the 12th November; germination indifferent. Those that did germinate, however, soon acquired a very healthy appearance, and in vigour were only exceeded by those of plots 3 and 1. Stems stout, branchy; the leaves full, close set, and of a deep glaucous green. Average specimens were 18 inches in height; leaves, 7 to 11 inches by 3½ to 5 inches broad; main-root, 5 to 7 inches; sparingly and irregularly branched upwards, with fibry extremities. Six plants weighed 14 oz., and in the air-dry state 3¼ oz. Opium, 1 seer 15 chittacks; seeds 43 seers 12 chittacks, of which 3 seers 4 chittacks was the produce of the first-class capsules.

6. This plot is somewhat over 4½ cottahs, and on the 12th November had an application of 36lb muriate of lime in 1½ maunds of powdered charcoal. Seeds were sown on the 14th November; germination irregular, from insufficient moisture,—indeed chiefly confined to the north and east side of the Kooree

ridges. The young plants, however, soon acquired a very healthy appearance, and compared favorably with the best in the surrounding plots. In selecting the following specimens, I remarked—plants healthy and very uniform in height; well advanced; stems stout, ramose; foliage copious and of a deep glaucous green. Average specimens, 19 inches high; leaves, 9 to 12 inches long by $4\frac{1}{2}$ to 6 inches broad; main-root short, 2 to 4 inches; irregularly branched; striking downwards and giving off numerous wide-extending fibres. Six plants weighed 18 oz., and in the air-dry state $4\frac{1}{2}$ oz. Opium, 14 chittacks; seeds, 7 seers 1 chittack; the produce of the better capsules being only 1 seer 3 chittacks.

7. This plot is of the same area as the preceding. On the 12th November it had an application of 36lb sal ammoniac (muriate of ammonia) mixed with $1\frac{1}{2}$ maunds of powdered charcoal. Seeds sown on the 14th November; germination very indifferent, from insufficient moisture. As in the preceding and other plots, the plants were largely confined to the cool sides of the compartment ridges. The plants throughout were very similar in habit to those on the preceding plot, and were chiefly distinguishable by the darker green of the foliage. Average specimens, 20 inches high; leaves, 9 to 12 inches long by $4\frac{1}{2}$ to 6 inches broad; main-root, 3 to 4 inches, with several deeply-penetrating fibry branches. Six plants weighed 20 oz., in the air-dry state, $4\frac{3}{4}$ oz. Opium, 10 chittacks; seeds, 18 seers 4 chittacks; good seeds, 2 seers 8 chittacks.

8. This plot, of less than 2 cottahs, had no manurial application whatever, and after the usual other preparations it was sown up on the 14th November. The crop was very much less vigorous than those on the manured plots adjoining; the plants having nearly all slender, simple stems, with pale green foliage, and tending to flower prematurely. Average specimens, 10 inches high; leaves, 4 to 6 inches long by $1\frac{1}{2}$ to $2\frac{1}{2}$ inches broad; main-root, 4 to 5 inches long; in most cases quite simple and but slightly fibry. Six plants weighed only 2 oz., air-dried, $\frac{1}{2}$ oz. Opium, 4 chittacks; seeds, 2 seers 5 chittacks, of which the latter only was the produce of good capsules.

9. A plot of less than 5 cottahs. On the 15th July it, along with the succeeding plot No. 10, was sown up with dheuroos (*Abelmoschus esculentus*). The germination was very fair, but the plants never acquired any vigour, apparently from the poverty of the soil, and were nearly all destroyed by the partial flooding of the plot about the end of July. The few surviving plants were cut and ploughed in on the 17th September. On the 1st of October I had 35 maunds of refuse poppy trash from the factory strewed over it and at once ploughed in; and again, on the 28th of October, it had an application of 1 maund sulphate of lime with 2 maunds powdered charcoal. Poppy-seeds were sown on the 12th November; they germinated freely, but the young plants suffered much from drought; and ultimately the crop was very thin and chiefly confined to the cooler sides of the compartment ridges and water-channels. The plant, however, was of free and robust growth; stems stout, freely branched; foliage copious, of a deep glaucous green. Average specimens, 18 inches high; the leaves, 6 to 8 inches long by 3 to 4 inches broad; tap-root, short, 3 to 4 inches, with several stout horizontal spreading and fibry rootlets. Six plants weighed 12 oz., when air-dried, $3\frac{1}{2}$ oz. Opium, 3 seers 1 chittack; seeds, 21 seers 8 chittacks, of which 3 seers 4 chittacks was the produce of the first-class capsules.

10. Plot of the same size as the preceding, like which, it had also on the 1st of October an application of 35 maunds of poppy trash, but without the sulphate of lime or any additional manure. Seeds were sown on the 13th November and germinated fairly well, but, as on other adjoining plots, the young plants suffered seriously from drought. Those left, however, succeeded well; forming robust freely branched plants, with copious and well developed foliage of a pale glaucous green color; average specimens, 20 inches high; leaves, 8 to 10 inches long by 3 to 4 inches broad; tap-root, 5 to 6 inches, stout, ramose, and fibry. Weight of six plants, $13\frac{1}{2}$ oz., in the air-dry state, $3\frac{1}{2}$ oz. Opium only 1 seer 3 chittacks; seeds, 16 seers 15 chittacks, and of that 2 seers only was the produce of first-class capsules. In comparing the produce of this plot with the preceding No. 9, without reference to the difference in

the manurial applications, the excess of opium from the latter plot is pretty clearly explained by a reference to column 10 of table, in which it is shown that while there were only 14 seers of first-class plants on plot 10, there were over 29 seers on plot 9; again, in column 20 of table, we find that the latter yielded 49 chittacks of opium, while the former yielded only 19 chittacks.

11. Rather over 13½ cottahs in extent. This plot and the succeeding No. 12 were sown up on the 12th July with arhar or rahur (*Cajanus indicus*) and lal sag (*Amaranthus gangeticus*); the latter failed from the partial flooding of the land about the end of that month, and the former, though surviving this, never acquired any vigour, and had quite a starved and stunted appearance when ploughed in on the 5th of September. On neither plot, therefore, did I regard it as a sufficient application for the poppy. Thus, on the 10th of October, I applied to plot 11, 5 maunds of castor-oil-cake with 2 maunds of charcoal: both reduced to a powdery state. Poppy-seeds were sown on the 3rd November. Though the crop was thin, the plants grew up rapidly; all rather of robust habit, freely branched with leaves of a deep glaucous green. Average specimens were 18 inches in height; leaves, 8 to 10 inches long by 3 to 4 inches broad; tap-root, 5 to 7 inches, stout, ramose, and fibry; six plants weighed only 9½ oz., in the air-dry state, 2½ oz. The opium weighed 5 seers 5 chittacks; seeds, 66 seers 14 chittacks, of which 8 seers 14 chittacks were the produce of first-class capsules.

12. A plot of the same area as the preceding. On the 10th October it had an application of 5 maunds mustard oil-cake with 2 maunds charcoal. Poppy-seeds were sown on the 2nd November; germination, however, was very poor from deficient moisture; and a subsequent sowing was also but indifferently successful. The crop throughout was very irregular and thin; largely confined to the cooler sides of the compartment ridges and water channels. In habit, &c., the plants were scarcely distinguishable from those on the preceding plot. Average specimens, 18 inches high; leaves, 8 to 10 inches long by 3 to 4 inches broad; tap-root, 5 to 7 inches, stout, ramose, and fibry. Six plants weighed 8½ oz., and in the air-dry state, 2¼ oz. Opium, 3 seers 1 chittack; seeds, 49 seers 8 chittacks, of which 5 seers 8 chittacks were the produce of first-class plants. On comparison with the opium produce of the preceding plot it will be observed that there is an excess of 2 seers 4 chittacks in favor of the latter: a result fully explained by reference to column 10 of table, in which we find that there are two and a half times more good plants on the preceding plot.

13. A plot of less than 2½ cottahs. In the beginning of October this plot had a liberal application of fresh cowdung, and again, prior to the sowing of the seed, it had an additional application of 20 seers superphosphate of lime, 16 seers of kharee neemuk (crude sulphate of soda), with 10 gallons refuse ammoniacal liquor of the gas works soaked up with 2 maunds of powdered charcoal; these several ingredients being well mixed prior to application. Seed was sown on the 5th November; the young plants sprung up but thinly, though, on the whole, very regularly distributed over the compartment. Stems throughout slender; very sparingly branched; the leaves narrow and of a rather pale glaucous green. I strongly suspect this was due to a deficient supply of water, as I observed that the plants on the sides of the water channels were much more robust, with broader and darker colored foliage. Average specimens were 18 inches high; leaves, 6 to 7 inches long by 2½ to 3 inches broad; tap-root, 4 to 5 inches, with few or no branches, and fibry only towards the apex. Six plants weighed 4 oz., and in the air-dry state, 1½ oz. Opium 1 seer 14 chittacks, *i.e.*, somewhat over 15 seers per beegha; a very fair yield, indeed, considering the thinness of the crop and the very large proportion of poor drug-producing plants. The total produce of seeds was 36 seers 7 chittacks, of which only 5 seers 11 chittacks were produced by the first-class plants.

14. This plot comprises about 2 cottahs. Seeds of sonai (*Crotolaria juncea*), were sown on it on the 10th July; the crop, however, was poor and thin, and after ploughing it in on the 4th September, I gave it a liberal application of cowdung and road scrapings. The poppy-seeds were sown on the

5th November, and germinated fairly well. The plants, though of somewhat slender growth, compared favorably with those on the preceding plot, being of a somewhat more robust growth, with darker colored foliage. Average specimens, 18 inches high; leaves, 6 to 8 inches long by $2\frac{1}{2}$ to 3 inches broad; tap-root, 4 to 6 inches, sparingly branched and fibry towards the apex. Six plants weighed 5 oz., and in the air-dry state, $1\frac{1}{2}$ oz. The produce of opium was 1 seer 2 chittacks; also a very fair produce, considering that out of the total 190 seers of air-dry plants only 23 seers 12 chittacks were really free drug-producers. The total quantity of seed produced was 19 seers 2 chittacks, of which 3 seers 9 chittacks was the produce of the best drug-producing capsules.

15. Plot of the same area as the preceding. On the 11th July it was sown up with seeds of sunflower, the shooriya-mookti of the natives (*Helianthus annuus*); the seeds, however, being the produce of the preceding cold weather crop, germinated very indifferently. When ploughed in on the 4th September, few of them had attained a height of 24 inches, while the foliage also was narrow and thin in texture. It would evidently have afforded but a poor manure, and I did not depend on it. The following, after well mixing the different ingredients, was the additional application :—3 maunds lime, 20 seers guano phosphate, 11 seers sajee mattee,—this is an impure carbonate of soda—(indeed frequently containing a higher percentage of the muriate of soda with a considerable amount of the sulphate), and 10 gallons gas liquor dried up in 2 maunds of powdered charcoal. The above mixture was applied on the 20th October, and the poppy-seeds were sown on the 8th November. The young plants were very regularly distributed over the compartments, though rather thin, as they were throughout of slender growth and but sparingly branched, with foliage of a pale glaucous color. Average specimens were 19 inches high; leaves, 5 to 7 inches long by 2 to $2\frac{1}{2}$ inches broad; tap-root, 5 to 7 inches, slender, nearly simple, with few fibres. Six plants weighed $4\frac{1}{2}$ oz., air-dried they were reduced to $1\frac{1}{4}$ oz. The produce of opium was 1 seer 2 chittacks; seed, 26 seers 2 chittacks, of which 3 seers 14 chittacks were the produce of good drug-yielding capsules. It is noteworthy that the quantity of opium yielded by this and the preceding plot is exactly the same; but in favor of the latter plot, we learn from the table that while it had only 190 seers of really good drug-producing plants, the other had 229 seers. The same seed being used on both plots, and all watered from one well, the cow manure would thus appear to be more favorable to the production of drug than the compound of earthy and alkaline salts, &c., applied to the present plot.

16. This plot comprises little more than 1 cottah. It had no manurial application whatever; seeds were sown on the 1st of November; the young plants sprung up somewhat thinly, and were also throughout of spare habit, with slender simple stems, and narrow, palish colored leaves; thus evincing unmistakable symptoms of ungenial conditions. Average specimens were 16 inches high; leaves, 4 to 6 inches long by 2 to $2\frac{1}{2}$ inches broad; tap-root slender, 4 to 6 inches, generally simple, with a few fibres at the apex. Six plants weighed $2\frac{3}{4}$ oz., and in the air-dry state $\frac{3}{4}$ oz. The produce of opium was 5 chittacks; seeds, 4 seers 6 chittacks, of which 8 chittacks was the produce of the best drug-producing plants.—I will here draw attention to the following results brought out in the table, which apparently show that in the absence of certain manurial conditions there is a tendency not only to produce a smaller quantity of drug, but even that of a poorer quality. Thus, in comparing the numbers of really productive plants in this and the preceding plot, we find (column 7 and 10 in table) that while in both there are about one-tenth of the plants really fair drug-producers, we find the former falling off in the proportion of drug; while again, in comparing the results of columns 19 and 20, we find in the present plot, that the crude and prepared drugs are as *two* to *one*, whereas in the preceding plot, it is scarcely *five* to *three*.

17. This plot consists of about 7 cottahs. It was sown up along with plots 17 (*a*) and 18 on the 22nd July, with a species of *Dolichos*, locally known as the bhora-sheem. It grew up with fair vigour and was cut and ploughed in

on the 1st September. On the 31st of October it had an additional application of 15 seers of the sajee mattee of the bazars mixed with one maund of powdered charcoal. Seeds were sown on the 23rd of November; they germinated very regularly. The young plants had rather pale colored foliage, and grew up with slender and generally simple stems. This I wholly attribute, however, to a deficient supply of water, and the excessive atmospheric dryness. Average specimens were 18 inches high; leaves, 6 to 8 inches long by 3 to $3\frac{1}{2}$ inches broad; tap-root, 4 to 6 inches, thick, ramose, and fibry throughout. Six plants weighed 5 oz., in the air-dry state $1\frac{3}{4}$ oz. The opium produce was 1 seer 3 chittacks; the seed produce of this, as well as the two following plots, was unusually small. This, I think, is attributable to the lancing of the young capsules for the first time while the plants had been suffering from drought; the extraction of the juice under these conditions having caused the abortion of a large percentage of seeds. The total quantity of seed produced was 9 seers 4 chittacks, of which the best drug-producing capsules yielded 1 seer 12 chittacks.

17*a*. The area of this plot is somewhat over $6\frac{1}{2}$ cottahs. In addition to the green manuring above noted, it had the following application on the 2nd November; 10 seers of khoree mattee, an impure creta or carbonate of lime; 4 seers of sulphate of soda, and 1 maund of powdered charcoal. The poppy-seeds were sown on the 25th of November; they germinated less freely than, but scarcely presented any other noteworthy difference from those on the preceding plot, and the average specimens of which may be taken as fair representatives of this also. The produce of opium was 1 seer 1 chittack; while the total seed produce was only 7 seers 4 chittacks, 1 seer 4 chittacks being the produce of the good capsules. In this plot we have again a minimum of seed: due, as I believe, to the extreme dryness of the soil and the almost flaccid condition of the crops when the young capsules were first lanced.

18. Plot of the same area as the preceding. This had no other application than the green manuring of *Dolichos* noted under plot 17. The poppy-seeds were sown on the 28th November. They germinated freely, but both in the young and advanced states, the plants were of a more slender habit than those on the two preceding plots. Average specimens were 18 inches high; leaves, from 5 to 7 inches long by $2\frac{1}{2}$ to 3 inches broad; tap-root, 4 to 5 inches, stout, ramose, and fibry. Six plants weighed 4 oz., in the air-dry state, $1\frac{1}{4}$ oz. The opium produce was 1 seer 1 chittack; seeds, 10 seers 6 chittacks, of which 1 seer 8 chittacks was the produce of the better drug-producing capsules.

I may note here that the seeds sown on the above plots (1–18) were sent me by the Sub-Deputy Opium Agent of Chupra. They were of the variety known as *Kaladantie*, and though containing, as will be seen by a reference to the tables, a very high percentage of poor drug-producing plants, they were, nevertheless, very true to their kind, containing very few other varieties. This, I regret to say, was not the case with those on which I have now to report, and which were supplied from Gya, which is generally considered one of the best drug-producing districts in the agency. I was greatly disappointed in them. The variety requested was that known as *Kutylea*, or the thistle-leaved poppy; 1 maund of it was sent me, and depending on its purity to kind at least, I sowed fully 3 beeghas with it. It proved in all respects most unsatisfactory, with scarcely ten per cent. of the Kutylea; there was quite a variety of other forms, *all singularly unproductive*. This will be at once seen by comparing the results shown on the table, plots 19 to 31 of which were sown up with the Gya Kutylea poppy.

19. This plot comprises full $3\frac{1}{2}$ beeghas. Seeds of til (*Sesamum indicum*) were sown on it, as also the succeeding plots, to and including plot 24. The green crop of til on the above was very poor; it was cut and ploughed in on the 3rd September, without any other manurial application; the plot was sown with poppy-seed on the 10th November. The plant was thin and rather irregularly distributed; stems slender, very slightly branched; the foliage, however, full, and of a deep glaucous green. Average specimens, 16 inches high; leaves, 5 to 8 inches long by $2\frac{1}{2}$ to 3 inches broad; tap-root, 3 to 5 inches, slightly

ramose and fibry. Six plants weighed 3 oz., in the air-dry state, ½ oz. The opium produce was ten chittacks; seed, 4 seers 10 chittacks, only 6 chittacks of which were the produce of the best drug-producing capsules.

20. This plot comprises over 5½ cottahs. To a green manuring of tíl in the beginning of September, it had, on the 31st October, 4 maunds of lime and 10 gallons refuse ammoniacal waters of the gas works dried up with 2 maunds of powdered charcoal. Poppy-seeds were sown on the 11th November. Plants of slender growth with palish colored foliage—probably due to our being unable to keep the soil sufficiently moist; the lime application having rendered it less retentive of water. Average specimens, 20 inches high; leaves, 5 to 7 inches long by 2 to 3 inches broad; tap-root, slender, 4 to 5 inches; fibry, but slightly ramose. Six plants weighed 3½ oz., air-dried, ¾ oz. Opium weighed 1 seer 2 chittacks; seed, 21 seers 4 chittacks, and of this 14 chittacks only were produced by the first class capsules.

21. Somewhat under 5½ cottahs. This plot had also a fair crop of green tíl plants ploughed in on the 3rd of September; again, on the 31st of October it had an application of 27 gallons gas liquor drunk up by 2 maunds powdered charcoal. Crop fairly vigorous, though rather thin; foliage of a pale glaucous green. Average specimens, 19 inches high; leaves, 5 to 7 inches by 2½ to 3½ inches broad; tap-root, 4 to 5 inches, ramose and fibry. Six plants weighed 5 oz., in the air-dry state 1 oz. The opium produce was 12 chittacks; seeds, 19 seers 2 chittacks, of which 1 seer 2 chittacks only were produced by fair drug-yielding capsules.

22. Plot of the same area as the preceding. This, in addition to the green-manure application noted above, had 5 maunds of lime applied on the 28th of October. Poppy-seeds were sown on the 11th November, and gave rise to a thin and irregular crop; plants fairly vigorous; foliage full and of a pale glaucous green. Average specimens, 20 inches high; leaves, 6 to 8 inches long by 3 to 3½ broad; tap-root, 4 to 5 inches, ramose and fibry. Six plants weighed 5½ oz., in the air-dried state 1 oz. The opium weighed 13 chittacks; seeds, 15 seers 15 chittacks, of which 14 chittacks only were produced by the better drug-producing capsules.

23. Area of this plot somewhat over 2 cottahs. On the 3rd of September a green crop of tíl (*Sesamum indicum*) was ploughed in, and poppy-seeds sown on the 13th November. Crop thin; the plants very sparingly branched, the foliage full but of a pale glaucous green. Average specimens, 20 inches high; leaves, 2½ to 3 inches broad; tap-root, 4 to 5 inches, slightly branched and fibry towards the apex. Six plants weighed 5 oz., air-dried, 1¼ oz. The opium produce was 7 chittacks; seeds, 6 seers 2 chittacks, of which only 6 chittacks were the produce of the better drug-yielding capsules.

24. This plot comprises full 5¼ cottahs. In addition to a green manuring of tíl, it had, on the 3rd of November, an application of 12 seers of common salt (chloride of sodium), 10 seers ammoniac sulphate, 10 seers *shorah* or nitre (nitrate of potash), 10 seers sajee mattee (an impure carbonate of soda), 3 maunds of lime, and 24 cubic feet of cowdung. The above being in the first instance well mixed together, and so afterwards with the soil to a depth of ten inches: there being an excess of saline ingredient, which, applied to the surface only, would to a certainty have destroyed the germinating crop. Plants of rather dwarf habit; stems stout and branchy; the leaves well developed, though of a palish color—no doubt attributable to the dryness of the atmosphere and a deficiency of moisture in the salinised soil. Average specimens, 17 inches high; leaves, 5 to 7 inches long by 2½ to 3½ inches broad; tap-root, 3 to 4 inches, ramose and fibry. Six plants weighed 6 oz. and in the air-dry state, 1¾ oz. The produce of drug was 15 chittacks; seeds, 18 seers, of which only 1 seer was the produce of the best drug-yielding capsules. It is worth comparing the results of this plot with No. 22 of nearly like area, but manured with lime only. We find, by reference to the tabular statement, that while there was but a difference of four chittacks in the produce of the better drug-yielding plants, No. 22 yields less opium by 2 chittacks and a similar quantity of good seeds than No. 24. With such seed, however, it was simply impossible to get anything like a fair

yield of drug from either plot, there being only 7 seers of fair drug-yielding plants out of some 93 seers of poorly productive.

25. Plot a little over 4 cottahs. It was sown up with mukai, or Indian corn (*Zea mays*) on the 14th of July; the crop in fair vigour was cut and buried on the 30th of August. This had no other application; seeds of poppy were sown on the 16th November. Crop thin and irregular; plants rather slender, sparingly branched; foliage fairly developed but of a palish green. Average specimens, 19 inches high; leaves, 5 to 7 inches long by $2\frac{1}{2}$ to 3 inches broad; tap-root, 5 to 7 inches, irregularly and sparingly branched, but rather fibry throughout. Six plants weighed 5 oz., air-dried, $1\frac{1}{4}$ oz. The opium produce was 11 chittacks; seeds, 17 seers, of which 1 seer only was yielded by the good capsule.

26. Plot scarcely 5 cottahs in extent. It was sown up with the *bherunda* or castor-oil plant (*Ricinus communis*) on the 12th of July. This crop, of poor and stunted growth, was cut and ploughed in on the 18th September. On the 6th of November it had an additional application of 10 seers of *shorah*, or nitre (nitrate of potash), mixed with 40 seers of charcoal. Seeds sown on the 16th November. Crop regular, though rather thin; plants of somewhat slender habit, sparingly branched; foliage full, though of a palish color. Average specimens, 18 inches high; leaves, 5 to 7 inches long by 2 to $3\frac{1}{2}$ inches broad; tap-root, 3 to 5 inches, fibry, but scarcely at all branched. Six plants weighed $5\frac{1}{2}$ oz., air-dried $1\frac{1}{4}$ oz. Produce of opium was 12 chittacks; seeds, 15 seers, of which 1 seer, 8 chittacks were the produce of the better drug-producing capsules.

27. Plot scarcely 2 cottahs in extent. On the 12th July it was sown up with tíl (*Sesamum indicum*); crop, a poor one, was cut and ploughed in on the 3rd September. No other manure applied. Poppy-seeds sown on the 16th of November; crop thin, the plants of slender habit, with narrow and palish colored foliage. Average specimens, 15 inches high; leaves, 4 to 5 inches long by $1\frac{1}{2}$ to 2 inches broad; tap-root, 4 to 5 inches, sparingly branched, and with few fibres. Six plants weighed 4 oz., air-dried, 1 oz. The opium weighed 10 chittacks; seeds, 5 seers 4 chittacks, of which 6 chittacks only were yielded by the better drug-yielding capsules.

28. Plot consisting of about 5 cottahs. In addition to a green crop of tíl ploughed in on the 3rd September, it had on the 5th September an application of 10 seers sajee mattee (an impure carbonate of soda), 10 seers of '*globber*' an impure sulphate of soda, ~~and~~ a native corruption of a well-known saline aperient, Glaubers salts,) mixed with 1 maund of powdered charcoal. The poppy-seeds were sown on the 17th November; crop thin, though upon the whole, regularly distributed; plants well developed; foliage of a pale glaucous green. Average specimens, 19 inches high; leaves, 5 to 8 inches long by $2\frac{1}{2}$ to $3\frac{1}{2}$ inches broad; tap-root, 5 to 8 inches, fibry throughout, but with very few branches. Six plants weighed $5\frac{1}{2}$ oz., air-dried, $1\frac{3}{4}$ oz. The produce of opium was only 5 chittacks, a very small quantity indeed, but this will be scarcely wondered at on a reference to the table, which shows that out of the 146 seers of air-dried plants, 8 seers 8 chittacks comprised all the really fair drug-producing plants. The total seed produce was 14 seers 10 chittacks, of which only 10 chittacks were the produce of the better drug-yielding capsules.

29. This plot consists of about 6 cottahs. In addition to a light manuring with green tíl plants, it had, on the 26th of October, an application of 3 maunds poppy oil-cake powdered and mixed with 2 maunds of charcoal. The poppy-seeds were sown on the 17th November; crop thin, though the plants individually were of robust habit, all less or more branched, with foliage of a pale glaucous green. Average specimens were 20 inches high; leaves, 6 to 9 inches long by $3\frac{1}{2}$ to 5 inches broad; tap-root, 5 to 7 inches, very ramose and fibry. Six plants weighed 14 oz., in the air-dry state, $3\frac{1}{2}$ oz. The produce of opium, however, was only 1 seer, but this need scarcely surprise us, seeing that the weight of the really good drug-yielding capsules was little more than $4\frac{1}{4}$ seers.—With such a minimum proportion of *structurally* fair drug-yielding capsules, manurial applications are really of no avail, as I shall subsequently illustrate and explain.—The total seed-produce was 21 seers 10

chittacks, of which 2 seers only were yielded by the good drug-producing capsules.

30. The area of this plot is the same as the preceding, like which, it had on the 3rd of September a green manurial application of tíl, differing, however, in having the second application of 3 maunds of linseed oil-cake with 2 maunds of powdered charcoal. The poppy-seeds were sown on the 18th of November, plants very similar in habit, &c. to those on the preceding plot. Average specimens, 20 inches high; leaves, 6 to 8 inches long by 4 to 5½ inches broad; tap-root, 4 to 6 inches, fibry but sparingly branched. Six plants weighed 12 oz., in the air-dry state 3 oz. The produce of opium, however, was only 13 chittacks; the proportion of the poor to the good drug-producers being in this case nearly *eight* to *one*. The total produce of seed was 20 seers 6 chittacks, and of this 2 seers 2 chittacks only was yielded by the more copious drug-producing capsules.

31. The area of this plot is about 6¼ cottahs. On the 12th July it was sown up with seeds of tíl (*Sesamum indicum*); a fair crop was produced, which was cut and ploughed in on the 4th of September. With no other manurial application poppy-seeds were sown on the 18th November; crop thin, and of very irregular habit; the majority of the plants with slender, almost branchless stems, and narrow foliage of a pale glaucous green; contrasting very unfavorably with those on the preceding plots, which had, in addition to the green manures, an application of oil-cake. The soil, as it appears to me, had been too far spent to be renovated by a single green manure crop, which ~~again~~, was ploughed in before it was sufficiently mature. Average specimens, 16 inches high; leaves, 4 to 5 inches long by 1½ to 2 inches broad; tap-root, 4 to 5 inches, slender, fibry, but scarcely at all branched. Six plants weighed 4½ oz., in the air-dried state, 1 oz. The produce of opium was 9 chittacks only, which is 4 chittacks under the plot of less area preceding. I do not, however, attribute this to the higher manurial condition of the latter, the results being wholly dependent on the proportion of poor and copious drug-yielding capsules, and in the present instance we find that while *plot* 30 had 5 seers of copious producers; *plot* 31 had only 3 seers. The total seed-produce was 13 seers, 12 chittacks, of which 1 seer only was the produce of good capsules.

32. This plot is upwards of 16¾ cottahs. On the 8th of May it was sown up with indigo seeds; though they germinated well, the excessive heat and drought of that month told hard on the young plants, and few indeed survived; the few that did survive were cut and ploughed in on the 31st of August. Again, on the 5th of October it had an application of 30 maunds of poppy trash with 4 maunds of lime. Seeds of the Kutylea *var.* (supplied by the Sub-Deputy Opium Agent of Shahabad) were sown on the 15th November. They germinated very well, and but for the limited supply of water would have afforded a very fair crop. I should also mention that the seeds produced a very pure crop, I mean, true to their kind only, as here also we find the really productive plants bearing a very small proportion to the others. Average specimens, 18 inches high; leaves, 6 to 10 inches long by 4 to 5 inches broad; tap-root, 5 to 8 inches, stout, ramose and fibry. Six plants weighed 9 oz., in the air-dry state, 3 oz. The produce of drug was 4 seers 5 chittacks; seeds, 69 seers 6 chittacks, of which 10½ seers were yielded by the really copious drug-producing capsules.

33. Plot of the same area as the preceding. On the 2nd May this plot was sown up with cheena (*Panicum miliaceum*); a very fair crop was produced, cut on the 31st August (prior to the maturation of the seed), and immediately ploughed in, 4 maunds of lime having been spread over it to accelerate decomposition. On the 17th November it was sown up with poppy; the variety sown was that locally known as *Dhooturiah*, and sent me by the Sub-Deputy Opium Agent of Bettiah. The seeds germinated fairly well, but the young plants were alike weak in habit and slow of growth; comparing most unfavorably with those on the adjoining plots. This, as I soon clearly saw, was due to the altered mechanical condition of the soil—the cheena in short had rendered it too light and porous thus decreasing too

greatly its powers of retaining moisture. The natives have an idea that cheena soon renders any soil on which it is grown very hot. They are quite right, as in decreasing the tenacity of the soil, and thus rendering it less retentive of moisture, its power of absorbing heat from the sun is proportionately increased: the *wet* is thus a *cold*, the *dry* a *hot* soil. In the present instance the effect of the cheena manure had a most marked effect, and to have kept the plot thus treated, equally moist with the adjoining would at least have required twice as much water. Thus, as a green manure for poppy, cheena should be confined to wet or tenacious soils. The tardy growth of the poppy in this plot is well shown by the average specimens, which were only from 8 to 10 inches high; leaves 4 to 6 inches long by 2 to $2\frac{1}{2}$ inches broad; tap-root, 3 to 4 inches, fibry, but very sparingly branched. Six plants weighed only 2 oz., in the air-dried state, $\frac{1}{2}$ oz. The produce of drug was 2 seers 2 chittacks; seeds, 47 seers 4 chittacks, of which $6\frac{1}{2}$ seers were yielded by the best drug-producing capsules.

34. This plot scarcely comprises $11\frac{1}{4}$ cottahs. On this plot seeds of sonai (*Crotolaria juncea*) were sown on the 3rd May; they germinated freely, and produced a heavy crop, which was cut and ploughed in on the 24th August. Poppy-seeds of the variety called *subja*, and very true to their kind were sown on the 12th of November; crop thin and irregular; the individual plants, however, were of a robust habit, generally freely branched, with full foliage of a deep glaucous green. Average specimens, 18 inches high; leaves, 6 to 8 inches long by 3 to 4 inches broad; tap-root, 5 to 7 inches, stout, ramose, and fibry. Six plants weighed 12 oz., air-dried, they were reduced to $2\frac{1}{2}$ oz. The produce of opium was 4 seers 15 chittacks; seeds, 77 seers 6 chittacks, of which only 6 seers 2 chittacks were the produce of the more copious drug-producing capsules.

35. Plot of the same area as the preceding. On the 3rd of May it was sown up with seeds of tíl (*Sesamum indicum*); crop fairly vigorous, it was cut and ploughed in as it began to flower on the 31st of August. Poppy-seeds were sown on the 28th of October. They were sent me without local name by the then Officiating Sub-Deputy Opium Agent of Hajipore. On showing their fruit, I found that there were about equal proportion of the common glaucous and the non-glaucous capsuled varieties. Crop thin and irregular; the individual plants generally vigorous, with stout, freely branched stems, and full foliage of a deep glaucous green. Average specimens, 18 inches high; leaves, 6 to 8 inches long by 3 to 4 inches broad; tap-root, 4 to 5 inches, fibry, but sparingly branched. The produce of opium was only 1 seer 10 chittacks, but this is scarcely a matter for surprise, seeing that on a reference to the table the proportion of poor and copious drug-producing plants is nearly as 8 to 1. The total seed produce was $46\frac{1}{2}$ seers, of which only $4\frac{1}{2}$ seers were produced by the better drug-producing capsules.

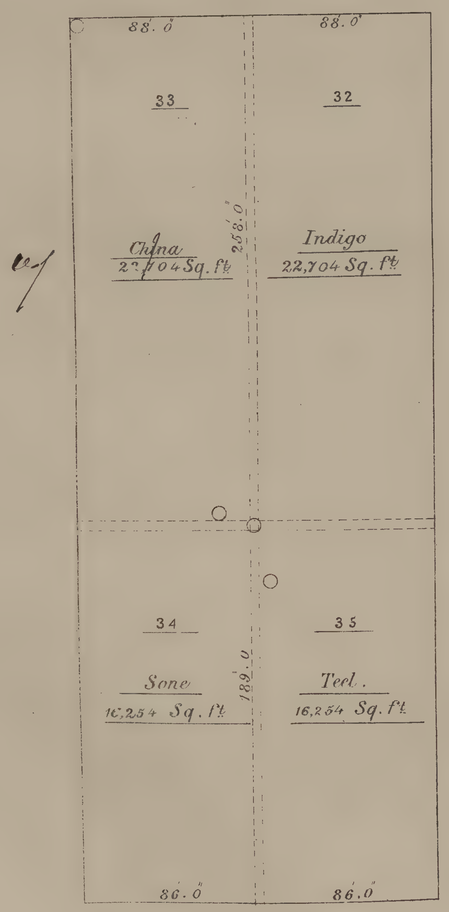
36. To facilitate comparison, I have given in the subjoined tabular statement an abstract of the several experiments detailed in the foregoing paragraphs. Thus, the first col. of table indicates the number of the experimental plot; the second, the area in square feet; the third, the number of plants on an area of seven square feet, *i.e.*, one compartment; in each case, that most uniformly filled with vigorous plants was selected as the sample, so as to enable us to form a true estimate of the general state of the crop on the respective plots. Col. 4 gives the total weight of plants under col. 3, in an air-dried state; col. 5, the weight of the plants in inches; while in col. 6 the weight of seed is stated. Again, in col. 7 I have given the actual weight of air-dried plant produced on each plot (the area being shown in col. 2); while col. 8 gives the estimated weight of a full and uniform crop, as estimated by col. 4; the difference between this and the real produce of the plot being shown in col. 9. The subsequent cols., 10 to 16, show the proportions of less or more copious and poor drug-producing plants in each plot; thus, col. 10 gives the total weight of air-dried plants bearing capsules with a minimum of 4 drug-yielding incisions. Even taking this low minimum, we find by comparing the figures in cols. 10 and 7 that there is still a very large proportion of the plants which have as a maximum but 3 drug-producing

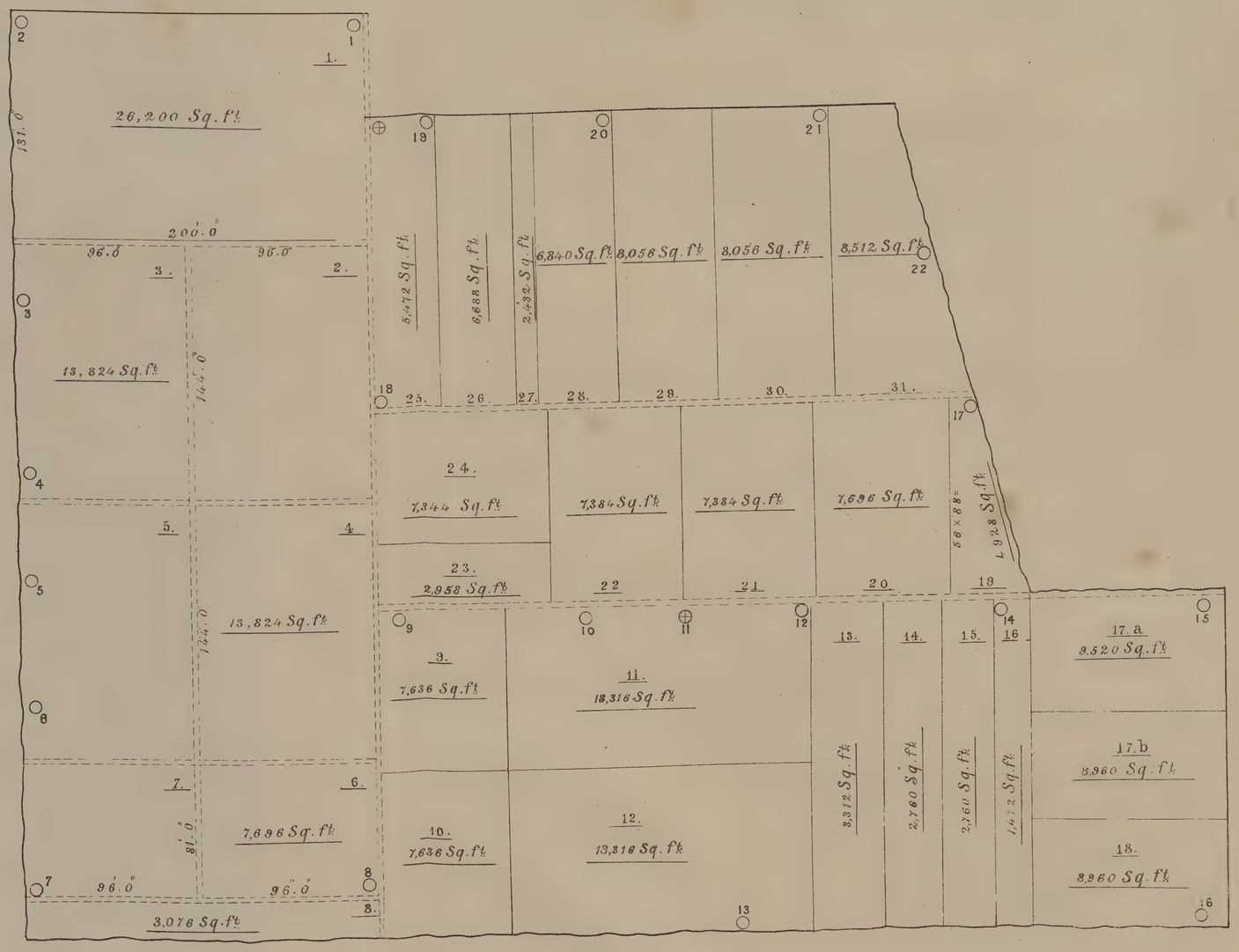
incisions on their capsules. In col. 11, the weight of capsules with a minimum of 5 drug-yielding incisions is given; in col. 12, that with 4 such incisions; while in 13, all those are included which have as a maximum, only 3 drug-yielding incisions. A comparison of the figures in this col. with the two preceding will at once show how largely the poor drug-yielding plants predominate in every plot. In cols. 14, 15, and 16, the seed produce of cols. 14, 12, and 13 are respectively given; col. 17 gives the number of times that drug was collected from each plot; col. 18 the period over which the collection extended; col. 19 the weight of crude drug, *i.e.*, drug as collected from the capsules; and in col. 20 the weight of prepared drug is given; which, I may remark, all exceeded the standard consistence. Lastly, in cols. 21 and 22 respectively, I have given the date of seed-sowing, and the number of waterings which each plot received.

P L A N

OF THE

METAPORE EXPERIMENTAL GARDENS





Lithographed at the Surveyor General's Office, Calcutta, August 1874.

A.—Meetapore Lands.—(Vide plan.)

1	2	3	4				5	6			7			8			9			10			11			12			13			14			15			16			17			18			19			20			21			22	
No. of plot.	Area in sq. ft.	No. of plants.	Sr.	Ch.	Ks.	Inches.		Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.	Ch.	Ks.	Seers.
1	26,200	152	1	14	0	30—46		6	1	501	0	0	7,018	0	0	6,517	0	0	195	8	20	19	0	22	1	1	120	8	8	83	8	10	381	12	0	4,459	0	0	4,077	4	0	108	14	19	5	3	381	12	0	4,459	0	0	4,077	4	0	108	14	19
2	13,824	135	0	14	0	20—32		3	0	263	12	0	1,791	0	0	1,528	0	0	40	8	10	12	0	14	4	1	36	0	0	65	0	6	280	4	0	3,648	0	0	3,367	12	0	84	0	10	5	0	280	4	0	3,648	0	0	3,367	12	0	84	0	10
3	13,824	140	1	13	2	30—48		7	2	336	12	0	3,456	0	0	3,119	4	0	54	8	13	2	0	2	4	0	88	8	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
4	13,824	111	1	15	0	30—40		6	1	300	0	0	2,073	0	0	2,001	0	0	32	0	6	1	0	1	2	0	42	0	0	60	0	5	309	2	0	3,483	0	0	3,173	14	0	39	0	8	6	1	309	2	0	3,483	0	0	3,173	14	0	39	0	8
5	13,824	196	1	12	0	18—36		4	1	57	8	0	1,648	0	0	1,545	0	0	12	8	4	2	0	2	4	0	40	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
6	7,696	72	2	0	0	30—48		5	0	103	0	0	411	0	0	394	8	0	2	4	0	1	0	1	2	0	36	0	0	60	0	4	309	2	0	3,483	0	0	3,173	14	0	39	0	8	6	1	309	2	0	3,483	0	0	3,173	14	0	39	0	8
7	7,696	120	1	8	2	24—40		6	2	16	8	0	1,364	0	0	1,184	6	0	29	4	5	0	0	0	1	0	24	0	0	46	0	4	381	12	0	4,459	0	0	4,077	4	0	108	14	19	5	3	381	12	0	4,459	0	0	4,077	4	0	108	14	19
8	3,072	120	0	15	0	20—36		5	0	229	3	0	709	0	0	479	13	0	41	0	10	3	0	3	4	0	48	0	0	65	0	6	280	4	0	3,648	0	0	3,367	12	0	84	0	10	5	0	280	4	0	3,648	0	0	3,367	12	0	84	0	10
9	7,636	110	1	4	0	38—50		6	0	190	0	0	517	0	0	327	0	0	23	12	6	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
10	7,636	145	2	4	0	34—50		7	2	179	10	0	1,364	0	0	1,184	6	0	29	4	5	0	0	0	1	0	24	0	0	60	0	5	309	2	0	3,483	0	0	3,173	14	0	39	0	8	6	1	309	2	0	3,483	0	0	3,173	14	0	39	0	8
11	18,316	133	2	6	0	24—42		6	0	132	8	0	2,454	0	0	2,321	8	0	14	4	2	0	0	0	1	0	24	0	0	65	0	6	280	4	0	3,648	0	0	3,367	12	0	84	0	10	5	0	280	4	0	3,648	0	0	3,367	12	0	84	0	10
12	18,316	188	2	0	0	24—42		6	0	375	8	0	6,213	0	0	5,721	12	0	99	8	16	1	0	1	2	0	24	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
13	3,312	197	1	8	0	27—40		4	0	229	3	0	709	0	0	479	13	0	41	0	10	3	0	3	4	0	48	0	0	60	0	5	309	2	0	3,483	0	0	3,173	14	0	39	0	8	6	1	309	2	0	3,483	0	0	3,173	14	0	39	0	8
14	2,760	171	1	5	0	24—42		4	0	190	0	0	517	0	0	327	0	0	23	12	6	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
15	2,760	167	1	2	0	26—38		3	2	229	0	0	443	0	0	214	0	0	29	10	6	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
16	1,472	174	1	2	0	23—39		3	2	80	8	0	236	0	0	155	8	0	8	8	0	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
17	9,520	160	1	12	0	24—40		6	2	148	12	0	2,380	0	0	2,231	4	0	15	8	3	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
17*a*	8,960	128	1	8	0	24—40		5	3	91	8	0	1,920	0	0	1,828	8	0	9	8	2	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
18	8,960	182	0	14	0	18—36		2	3	130	7	0	1,120	0	0	989	8	0	13	8	2	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
										4,141	0	0	44,999	0	0	40,904	0	0	692	2	133	12	0	183	4	0	785	12	0	321	12	0	16,524	0	0	15,101	6	0	1,422	10		1,378	10	0	14,976	0	0	13,697	6	0	150	0	28	7	0	293	8	0	16,524	0	0	15,101	6	0	1,422	10		1,378	10	0	14,976	0	0	13,697	6	0	150	0	28

B.—Meetapore Lands.

19	4,928	210	1	8	0	22—40		4	0	50	8	0	1,656	0	0	1,005	8	0	4	4	1	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
20	7,696	164	2	14	0	24—42		4	1	135	12	0	3,160	0	0	3,024	4	0	19	4	1	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
21	7,384	215	1	4	0	18—32		4	0	106	0	0	1,319	0	0	1,213	0	0	8	4	1	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
22	7,384	132	0	12	0	18—30		3	0	92	0	0	791	0	0	699	0	0	6	12	3	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
23	2,958	140	0	12	0	18—30		3	2	20	8	0	316	0	0	295	8	0	3	4	0	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
24	7,344	108	0	14	0	24—39		2	3	93	12	0	918	0	0	824	4	0	7	0	2	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
25	5,472	169	0	12	0	24—38		3	0	90	10	0	586	0	0	495	6	0	8	4	2	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
26	6,688	308	1	6	0	12—36		4	3	131	0	0	1,313	0	0	1,182	0	0	10	0	3	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
27	2,432	225	0	8	0	8—32		0	4	19	0	0	160	0	0	140	8	0	6	0	0	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
28	6,840	201	0	14	0	24—39		2	3	146	0	0	855	0	0	709	0	0	8	8	1	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
29	8,056	170	1	3	0	24—41		4	1	164	8	0	1,367	0	0	1,202	8	0	26	0	4	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
30	8,056	123	0	14	0	30—41		3	0	184	0	0	1,007	0	0	923	0	0	22	8	5	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
31	8,512	116	1	12	0	20—40		4	1	144	8	0	2,128	0	0	1,983	8	0	20	0	3	1	0	1	3	0	36	0	0	112	8	6	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
										1,378	10	0	14,976	0	0	13,697	6	0	150	0	28	7	0	293	8	0	16,524	0	0	15,101	6	0	1,422	10		1,378	10	0	14,976	0	0	13,697	6	0	150	0	28	7	0	293	8	0	16,524	0	0	15,101	6	0	1,422	10		1,378	10	0	14,976	0	0	13,697	6	0	150	0	28

C.—Meetapore Lands.

32	22,704	114	1	6	0	24—39		5	3	381	12	0	4,459	0	0	4,077	4	0	108	14	19	5	3	381	12	0	4,459	0	0	4,077	4	0	108	14	19	5	3	381	12	0	4,459	0	0	4,077	4	0	108	14	19
33	22,704	199	1	2	0	18—30		5	0	280	4	0	3,648	0	0	3,367	12	0	84	0	10	5	0	280	4	0	3,648	0	0	3,367	12	0	84	0	10	5	0	280	4	0	3,648	0	0	3,367	12	0	84	0	10
34	16,254	153	2	2	0	28—40		6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12	6	1	451	8	0	4,934	0	0	4,482	8	0	90	8	12
35	16,254	140	1	8	0	20—40		6	0	309	2	0	3,483	0	0	3,173	14	0	39	0	8	6	1	309	2	0	3,483	0	0	3,173	14	0	39	0	8	6	1	309	2	0	3,483	0	0	3,173	14	0	39	0	8
										1,422	10		16,524	0	0	15,101	6	0	322	6	50	4	0	59	8	0	321	12	0	114	1	6	0	22,704	0	0	22,704	1	0	114	1	6	0	22,704	0	0	22,704	1	0	114	1	6	0	22,704	0	0	22,704	1	0	114	1	6
										1,422	10		16,524	0	0	15,101	6	0	322	6	50	4	0	59	8	0	321	12	0	114	1	6	0	22,704	0	0	22,704	1	0	114	1	6	0	22,704	0	0	22,704	1	0	114	1	6	0	22,704	0	0	22,704	1	0	114	1	6

37. For the sake of comparison, I append two tables, A and B, showing the opium produce of the above and adjoining lands under the native cultivators. In table A, the opium produce of the lands now forming the Meetapore Experimental Garden is given; the results being in part those of the seasons 1871, 1872, and 1873, as several of the Assamees had given up opium culture on these lands prior to my taking them over. Table B gives the opium and seed-produce of lands in the vicinity of the Meetapore gardens under the native cultivators during the past season.

TABLE A.

Names of Assamees.	Area of land.		Opium.	
	Beeghas.	Cottahs.	Seers.	Chittacks.
Dyaram	2	2	10	0
Goopeeram	0	10	3	8
Sheershoyob	2	0	9	0
Jhumock	1	0	7	0
Tohul	0	15	5	8
Jogarjun	0	10	3	0
Kamee	1	0	8	0
Chettee	0	15	4	12
Bheecaree	1	0	8	0
Mohunriot	2	0	7	0
Chunnon	0	15	4	8

TABLE B.

Names of Assamees.	Area of land.		Opium.		Seed.	
	Beeghas.	Cottahs.	Seers.	Chittacks.	Mds.	Seers.
Nilamee—Mutto	0	10	2	8	1	0
Bulacan	1	0	5	0	2	0
Ram Sarun	1	0	5	0	2	0
Ram Nath	0	10	2	8	1	0
Teeluckdharee	0	10	3	0	1	10
Gopee Nath	1	0	7	0	2	15
Metun Gorait	2	0	11	0	4	15
Chetta	1	0	6	8	2	25
Gopallee	0	15	5	8	2	20
Dal Chund	1	0	6	0	2	15
Fuckeerah	1	0	7	0	2	30
Protun	0	10	2	12	1	5
Sunkur	0	10	2	8	1	0
Munjhee	0	10	2	0	0	35

38. Table A shows that the Meetapore lands under native cultivators gave an average produce of about 5 seers 10 chittacks of opium per beegha, whereas the average produce of these lands under me for the past season was only 4 seers 9 chittacks per beegha. On the other hand, by comparing the maximum produce of the individual plots, we find that the excess is in favor of my experimental plots; the maximum produce of the native plots being 8 seers per beegha, whereas the produce of the best garden plots, was from 9 to 10 seers. Table B gives the opium and seed produce of the finest plots of poppy which I saw during the past season in the vicinity of Meetapore. The most productive plot, that of Gopallee, which yielded about $7\frac{1}{2}$ seers of opium per beegha, was heavily manured with nightsoil from the jail. The poppy was extremely vigorous, uniform, and early; the variety being that called Teyleah. I visited this plot frequently during the collecting season, and observed that it contained a large percentage of very poor drug-producing plants. This was the case also with all the other plots, some indeed, containing a much higher percentage of poor drug-producing plants. In no case was there any want of manurial conditions, the plants being all vigorous and healthy; and no one could have examined them as I did without being convinced that the real cause of the fluctuating and low returns of opium is the mixed condition of the crops and

the predominance of poor drug-yielding plants. The first step to any radical improvement is clearly selection of the seed from the more copious drug-producing capsules. This, however, I shall show more particularly in a subsequent part of my report. In the mean time I will only remark, that the state of cultivation or the vegetative condition of the plant is no criterion whatever of the opium produce, this being wholly dependent on the relative proportions of poor and copious drug-producing plants; so that a very indifferently cultivated plot may prove considerably more fertile than another which has had every advantage of manure and cultivation. All this would be obviated by the selection of seed; the opium produce to a certainty would be very largely increased, cropping altogether less precarious, and the best cultivator might then depend on having the most productive crops.

SECTION II.

DEEGAH—OUTSIDE LANDS. (*Vide* PLAN).

1. I include in this paragraph plots 1 to 4 (comprising an area of $36\frac{1}{2}$ cottahs), the results having been so poor and unsatisfactory that it is not worth while giving them separately. I had each of the plots half-trenched in September, and subsequently had them repeatedly dug over, the clods well broken, and the tubers of *moota* (with which the lands were fairly overrun), as I thought, pretty well cleared out. Very large quantities of the tubers, anyhow, were taken out and burned, but shortly after the land had been watered and the poppy-seeds sown (this was on the 19th of October), it was again studded with the green tops of the *moota-grass* leaves. The poppy-seed germinated freely enough, but long ere it reached a stage at which I could have safely eradicated the *moota*, the soil had been quite overrun with the latter, and scarcely a plant of poppy left. I had thus to dig all over again, weeding out as carefully as possible the *moota* tubers. I resowed the plots with poppy on the 24th of November; but though the seeds germinated fairly well, the plants never acquired any strength, so thoroughly had the soil been exhausted, and the produce of drug and seeds were alike poor. The total quantity of plant produced weighed, when air-dried, 300 seers, of which only 35 seers were fairly fertile plants. The total seed produce was about $53\frac{1}{2}$ seers, and of this only 2 seers 13 chittacks were yielded by the really good drug-producing capsules. The produce of opium was 2 seers 9 chittacks only.

2. This plot consists of about 8 cottahs. After a half-trenching in September, and frequent subsequent breakings up with the plough, and hand-picking of *moota* tubers, it was sown up with poppy-seeds on the 26th of October; the variety used was the broad-leaved *kutylea* from Shahabad. Prior to the sowing of the seed this plot had been twice well soaked with water from an adjoining tank, which was quite over-grown with water-weeds, (*Hydrilla verticillata*, *Ceratophyllum verticillatum*, and one or two species of *Chara*), all excellent manure plants, giving off, as the water dried up, a most powerful and offensive smell (sulphureted and phosphoreted hydrogen). After the germination of the young plants, they were thrice watered from the tank, prior to its getting quite dried up in the end of December. The plot was subsequently watered seven (thus in all twelve) times from an adjoining well; the last drug collection being made on the 21st of March. The crop, as compared with that on adjoining plots watered from the wells only, was very superior. The total produce of air-dried plants was 142 seers, of which 40 seers only were fair drug-producers. The total produce of seed was 49 seers, and of opium 2 seers $\frac{1}{2}$ chittack. It thus altogether compares very favorably with the results of the crops on the preceding plots; the soil being similar throughout, the only additional advantage which the present plot had, being the five waterings with the decomposing-weed water.

3. This plot comprises over $10\frac{1}{2}$ cottahs. As regards preparation of the soil, it had exactly similar treatment with the preceding plots. Six cottahs (*a*) had no manurial application whatever, while the remaining $4\frac{1}{2}$ cottahs (*b*), were saturated with strong jute-water (*i.e.*, water in which a large quantity of jute plants had been macerated), all subsequent waterings being in both

cases from the same well, and in all twelve applications to each. The contrast of the two crops was very striking; while the jute-watered plants were green and vigorous, the other throughout was of weak and slender growth. The total amount of air-dried plants was more than doubled on the former portion as compared with the latter, while there was an equal increase in the drug produce, as will be seen by a reference to the tabular statement of the outer lands. The total produce of opium on the plot was $11\frac{1}{2}$ chittacks; of seeds, 19 seers 12 chittacks, of which 3 seers 14 chittacks were produced by the more copious drug-yielding capsules. The seeds, as in all the preceding plots, were of the *kutylea* variety, and sent me by the Sub-Deputy Opium Agent of Shahabad. All proved very true to their kind, though, as will be seen from the tabular statement, the copious drug-producers bear but a small proportion to the poorly productive sorts.

4. This plot comprises over $12\frac{1}{2}$ cottahs. The soil seems to have been quite exhausted with the *moota* grass which I could only keep partially in check, as the young poppy never acquired any vigour, and when reaped, only gave a total of $42\frac{3}{4}$ seers of air-dried plants. The drug produce was 7 chittacks; seeds, 8 seers 12 chittacks, and of this only 6 chittacks were yielded by fair drug-producing capsules.

5. This plot comprises about $11\frac{1}{2}$ cottahs, and proved to be one of the most sterile of all. Indeed, but for the various *steeps* to which the seeds were subjected prior to sowing, I scarcely think the young plants could have survived. Anyhow, in no plot had we anything like the number of poppy-miniatures. In plate 3, a few such are drawn to the natural size; strangely enough, though thus diminished in all their parts, they fully completed their vegetative and reproductive functions; they had simple, tiny, wiry stems, scantily set, with miniature leaves of a papery-texture, and terminated by a little butter-cup-like flower with some three or four stamens and seed-yielding capsules with three or four-rayed stigmas. The total produce of air-dried plants on this plot was 43 seers; of seeds, 9 seers 5 chittacks: and of opium 7 chittacks. In the tabular statement I have separated the plants into three sizes, (all being included in from 4 to 36 inches), and given the total weight and seed produce of each separately. The seeds were steeped in solutions of *ammoniac* and *soda-sulphates*, *soda-nitrate*, *guano-phosphate*, *cowdung* and *urine*, and as they were taken out of the *steeps* they were at once dried in lime or charcoal and sown. There was no well-marked difference in the crops from the seeds thus treated, but there is this to be said, that the lines on which the seeds were wholly untreated or subjected to a plain water steep, were nearly void of plants, whereas the others were upon the whole very regularly covered with miniature plants. The steeps would thus appear to have simply enabled the young plants to establish themselves in the soil, the manurial effect scarcely outlasting the seed-leaf stage, and thus the young plants were left as starvelings in a barren soil.

6. This plot comprises upwards of 28 cottahs. I intended having it turned over with an English plough, but though I made several attempts with two and even three pairs of bullocks, I could make nothing of it, so dry and hard had the soil become under the prolonged drought. So much indeed was this the case, that in my last attempts, both the coulter and sock or share were much bent and would evidently soon have given way. I, however, delayed the digging of this plot with the kodalee in the expectation of rain, which never came. I had ultimately to dig it over, and it was the 29th of November before I got any of it ready for sowing. This comprised about 9 cottahs. I had this sown in the usual way, and subsequently drawn up in ridges 9 inches apart with the drill-rake. The germination was very good, and the young plants grew up with fair vigour but nearly all confined to the north and, of course, the cool side of the ridges. The soil turning out, like most of the land adjoining, extremely poor, the plants never acquired any vigour, though the crop was throughout very regular. From the success of the young plants in this instance, and from the fact that one everywhere observes the most vigorous plants on the cool sides of the compartment ridges (indeed lines of them, when

scarcely a plant is to be seen on the plane surface), I do think the system is worth general adoption. The produce of the 9 cottahs thus treated was 110 seers of air-dried plants ; but of such a wretchedly unproductive character was the seed that from all these there were but 10 seers of really fairly productive plants selected. The total seed produce was 21 seers 10 chittacks, of which $1\frac{1}{4}$ seer only were yielded by fair drug-producing capsules ; of opium I had only $9\frac{1}{2}$ chittacks. The seed was sent me by the Benares Agent and was procured from Bhagulpore, in the Goruckpore division. With the exception of the so-called *kutylea* from Gya, I have yet seen no poorer drug-producers. I had it sown on several of the plots yet to be noted, and thus under varied soil conditions, but in all it produced but a very small quantity of drug. I was much disappointed in this batch of seed, it being of the *kalodantie var.*, which is usually a fair drug-producer. Unlike the Gya *kutylea*, however, I had here no mixture of seed; nearly every plant as it attained maturity acquiring the purply-black stalk peculiar to the variety, and from which it has its native name *kalodantie*, *i.e.*, black-stalked.

The remaining portion of the plot was sown from the 2nd to the 12th of December, but though the plants germinated fairly well, they got quite overrun with *moota* grass, and I had ultimately to dig all over again, and as it was much too late for poppy, I sowed all over with cheena (*Panicum miliaceum*).

7. This plot comprises upwards of 25 cottahs. It had a half-trenching in September, and after frequent ploughing and weed-picking it was sown up with poppy-seed from the 6th to the 8th of November. The plot was divided into three parts, *A*, *B*, and *C*. *A*, comprising about $8\frac{1}{2}$ cottahs, was sown with *kutylea*, or thistle-leaved poppy-seed from Gya ; these only being used which had a specific gravity exceeding 1·204. *B*, comprising about $7\frac{1}{4}$ cottahs, was sown with the same variety, the seeds varying in specific gravity from 1·056 to 1·200. *C*, comprising an area of about 9 cottahs, was sown with such of the above seeds as floated on water. The results were well marked in so far as relates to the vigour of the plant and size of capsule; thus, *A* bore a total of 165 seers of air-dried plants, of which 24 seers, *i.e.*, about one-seventh, were good plants : all, however, were of a singularly robust habit, freely branched and bearing capsules of large size. The total produce of seed was 44 seers 6 chittacks, of which, however, only $7\frac{1}{4}$ seers were produced by the fairly copious drug-yielding capsules. The produce of opium was 2 seers 11 chittacks. The total weight of air-dried plants on division *B* was $54\frac{3}{4}$ seers, of which $6\frac{1}{4}$ seers, *i.e.*, about one-ninth, were fairly productive plants. As regards habit, the plants were very similar to those on the preceding division, but there was a considerably greater percentage of small capsules. The total seed produce was 11 seers 10 chittacks, of which 1 seer only was yielded by the more copious drug-producing capsules. Opium weighed 12 chittacks. The total weight of the plants raised from the light or water-floated seeds was only 21 seers, amongst which there were really no capsules yielding drug to more than four incisions, and thus all were included in the second and third classes. The total produce of seed was 4 seers 12 chittacks, of which $1\frac{1}{4}$ seer were produced by four-lanced capsules. Opium weighed only $4\frac{1}{2}$ chittacks. These results are of considerable interest, thus, by reference to the tabular statement we find that while the seeds of highest specific gravity produced the heaviest crop, and also the largest number of fairly copious drug-producing plants, nevertheless the seeds of medium specific gravity included a higher percentage of the most copious drug-producers, as will be seen by comparing the results of columns 3 and 10, and also 4, 7, and 10. Again, from the results of *C* it is plainly evident that the light or water-floated seeds are very poorly productive. As regards the present experiment, it would appear that the seeds of medium specific gravity, and the most bulky, (this is tested by sifting small quantities of the seed, on sieves of one-twenty-fourth and one-thirtieth of an inch on the side of the square) are also the most productive of drug. I had, on the other hand, anticipated that those of the highest specific gravity would have been more productive than lighter seeds of larger size ; in so far as my experience goes this is not the case.

8. This plot consists of about 11 cottahs. It was half-trenched in September, ploughed and hand-weeded frequently until the 20th of November, when it was sown with seeds of the *kalodantie* variety from the Goruckpore division of the Benares Agency. The seeds were sown in *drills*; they germinated remarkably well, and, but for their hav ng been suddenly attacked by large numbers of the grub of a small moth, I should have had a very full crop in so far as regards plant. On observing the destruction caused by this grub, I quickly arrested it by dusting the plants over in the evening with quicklime. I had no further trouble with the grub on this plot, though unfortunately it had committed much damage ere I observed it. I have figured this moth in its different stages, as being one apparently common to the poppy in both Agencies. The seeds, as I have said, were sown on the 20th of December, and on the 25th of December the drills were studded with the young plants. The active germination being no doubt due to the moist condition of the soil in the furrows. Thus, in so far as my experience goes, I should recommend furrow or *drill* sowing for all light, dry, or sandy soils, while for those of a clayey, strong or tenacious character, I would, on the other hand, recommend ridge-sowing. I feel confident that by the adoption of such modes on what the natives rightly enough call *hot* and *cold* soils, the poppy would be very greatly benefitted. The total weight of air-dried plants was 145 seers, of which only 18 seers were fairly copious drug-producers. Seed produce, 24 seers, and of this there were only 4 seers 5 chittacks from the better drug-producing capsules; while of opium the produce was but 2 seers 9 chittacks.

9. This plot comprises upwards of 14 cottahs. It had in all respects similar treatment to the preceding, and was sown up with poppy-seeds on the 15th of November; germination free and regular by the 25th instant; the seeds used were the *kalodantie* variety. Thus about $3\frac{1}{2}$ cottahs were sown with Goruckpore seed, that only being used which was retained by sifting on the twenty-fourth of an inch seive; the remaining portion of the plot, upwards of $10\frac{1}{2}$ cottahs, was sown with seeds of the same variety from Chupra, that only being used which was retained by the above sieve. The results are of considerable interest, as while both plots produced a fairly full and vigorous crop, it will be seen on referring to the tabular statement that there are a very much larger number of poor drug-producers in the former than the latter. The Assamees under me were greatly surprised with the results of the plot sown with Goruckpore seeds, it being such a full, regular, and healthy crop, though nearly all the capsules were of very small size. Thus, on the first collection of drug, it yielded 2 chittacks; on the 2nd, 10 chittacks; on the 3rd, (beginning already to decrease) 8 chittacks; on the 4th, 2 chittacks; on the 5th and last, only $\frac{1}{4}$ chittack. I was indeed very much struck with the results of this plot, as the plant, though thus drug-exhausted, was in full vigour and clad in foliage of a deep glaucous green. The collection of drug on the adjoining division was as follows:—1st, $2\frac{1}{2}$ chittacks; 2nd, 11 chittacks; 3rd, 16 chittacks; 4th, 14 chittacks; 5th, 14 chittacks; 6th, $8\frac{1}{2}$ chittacks; on the 7th and last, 3 chittacks, or in all 4 seers $4\frac{1}{2}$ chittacks; and of good opium, 3 seers $11\frac{1}{2}$ chittacks; whereas in the other case I had only 1 seer of good opium to 1 seer $6\frac{1}{4}$ chittacks of crude drug. The proportion of non-productive and productive plants, &c., is given in the tabular statement.

10. This plot comprises about $10\frac{1}{4}$ cottahs. It was sown on the 26th of November with seeds of the variety *kalodantie* from the Benares Agency; one-half (*a*) being sown with untreated seeds; the other (*b*) with seeds soaked in a solution of sulphate of copper and dried in quicklime. I thus treated the latter in case of the seeds being affected with the poppy mould, which I had reason to believe was less or more prevalent in the divisions of the above Agency during the preceding season. The germination was very fair throughout the plot; the crop full and vigorous. The poppy mould broke out on both divisions towards the close of January, and was quite as prevalent on the seed-steeped portion as on the other; it also ran its course on both as on all my earlier sown crops, all the applications I could think of being unavailing. As it had occurred to me that the drug-yielding qualities of the poppy might

possibly be affected by the prevailing practice of collecting the petals of the poppy prior to their natural fall. I allowed the petals on the half of this plot (*a*) to fall off naturally, the other (*b*) I had collected in the ordinary way. The result, as shown by reference to the tabular statement, was that with an increase of opium on (*b*), proportionate only to the greater produce of plants, there has been a marked increase in the production of seeds. Thus, while the total produce of seeds on plot (*b*) was $42\frac{1}{2}$ seers, that of (*a*) was only $25\frac{1}{4}$ seers, or nearly one-third less. I had not previously paid any particular attention to the collecting of the flowers, which, as we all know, forms the shell or covering of the opium as sent to China. On observing the collection of the petals, however, it appeared to me highly probable that the process was very favorable to the plants fertilization, and not at all likely to otherwise affect the secretion of drug. This will be at once understood when I say that by the usual mode of collecting the petals, their natural fall is but anticipated by a few hours. Thus, as a rule, the earlier flowers cast their leaves about the close of the third or in the morning of the fourth day after their expansion. The petal collectors go over the plots daily about noon, and know well, from the dry, shriveled, and twisted stamens, what flowers are ready for collection. No force, or at least a minimum, is used in gathering the petals, the open hand being placed under the flower, and as it is passed up over the capsule, the forefinger and thumb gently clasp the petals, causing at once, if mature, their disarticulation. Should this not happen, the flower is passed over for another day. The process as thus carried out rarely causes the loss of a drop of the plants milky juices, and can thus do no possible injury ; on the other hand, I have found it beneficial to the plant as perfecting fertilization. The anthers burst and discharge the pollen a few hours after the expansion of the flower, whereas the stigmatic rays are not ready to receive the pollen before the second or even third day, when it is perfectly developed. Now, on looking down on an expanded poppy flower, one generally observes the base of its cup thickly dusted with pollen, whereas the stigmatic rays, as a rule, have but a few grains. Thus, unless winds prevail, the pollen on the petals is lost, being scarcely disturbed by the natural fall of the petals. On the other hand by the usual mode of collecting the petals, the stigmas of the individual flowers are not only dusted with pollen, but the gentlest breath of air buoys it and carries it to other flowers. We do indeed find insects of several kinds occasionally haunting poppy flowers for their pollen, but rarely in such numbers as to regard them as important agents in the plants' fertilization. This important function is, in my opinion, excellently affected and indeed, largely dependent on the mode of collecting the flowers for the opium shells. I feel certain from the results of my experiments during the past season that this would be fully borne out by careful inquiry and comparison of the quantity of seed produced by the poppy in those districts where the so-called leaves are and are not sent into the opium factory.

11. This plot comprises upwards of $9\frac{1}{4}$ cottahs, about 7 of which were sown upon the 17th of November with one of the Malwa varieties of poppy called *Leela* (the seed having been supplied by the Sub-Deputy Opium Agent of Gya), the remaining portion with seeds of the variety *kalodantie* from Goruckpore. The crop of the Malwa poppy was thin, but the plants were of robust habit, the stems tall and stout, but very sparingly branched. In this respect, in the texture and indentations of the leaves, in the color of the flowers with their usually deeply-fringed petals and the large stigmatic rays, the Malwa varieties of the opium poppy are, as I shall subsequently show, readily distinguished from those common to the Behar and Benares Agencies. The proportion of poor to copious drug-yielding plants in the Malwa varieties is much the same as we have found it in the other varieties. The total produce of seed was 19 seers 10 chittacks, of which 6 seers were produced by the more copious drug-yielding capsules. Opium weighed 1 seer 3 chittacks. The total produce of the crop of the *kalodantie* variety is shown in the tabular statement.

12. This plot comprises upwards of $21\frac{3}{4}$ cottahs; it was divided as follows:—(A) comprising upwards of 3 cottahs; (B) $6\frac{1}{3}$ cottahs; (C) $6\frac{1}{4}$ cottahs; and (D) $6\frac{1}{3}$ cottahs. (A) was sown on 29th of November with the *Lukria var.* of the Malwa poppy. The seed germinated but thinly; otherwise, the crop

would have been good, as the plants individually were well developed. Like all the Malwa varieties which I have yet seen in cultivation here, it was little disposed to branch and had but poorly developed roots, thus suffering much in gusty weather unless they are grown very close together. In describing the several varieties of Malwa poppy in a subsequent paragraph, I shall explain this more fully. The total weight of air-dried plant on this plot was only 51 seers, and of this $7\frac{1}{2}$ seers produced a fair amount of drug, while the other yielded only from one to two and three incisions. The produce of seed was 15 seers, $6\frac{3}{4}$ seers being the produce of the more copious drug-producing capsules; the produce of opium was $12\frac{1}{2}$ chittacks. (B) This portion was sown with seeds from untapped capsules, and the produce of one of my last season's experimental plots at Goolzarbagh. The variety being the *Uggarya* of the Malwa sorts. The total weight of plants was 80 seers, and of this 21 seers, or about one-fourth, were fair drug-producers. The total seed produce, 13 seers 8 chittacks, and of this $5\frac{1}{4}$ seers were produced by good capsules. Opium 15 chittacks. (C) This portion was sown with the seed from tapped capsules of the above variety, and also the produce of a plot in the previous season's experiments at Goolzarbagh. The total weight of plants on this plot was 117 seers, of which 35 seers were fairly copious drug-producers. The total produce of seeds was 32 seers, of which $9\frac{1}{2}$ seers were the produce of the fuller drug-yielding capsules. Again, I had in opium 1 seer 9 chittacks, so that we have, both in good seeds and opium, a considerable increase on the results of the preceding plot in which the seeds used were from untapped capsules of the *Uggarya* poppy. (D) This portion was sown with seeds of a Malwa variety called *Gunjajule;* these were the produce of lanced capsules in the experimental gardens at Goolzarbagh. The total weight of plants was 106 seers, of which $20\frac{1}{2}$ seers were fair drug-producers; seed produce, 27 seers, and of this 9 seers were yielded by the more copious drug-yielding capsules. Opium 1 seer 7 chittacks.

13. This plot comprises over 10 chittacks. Lying as it does on the banks of the river, I arranged to water it regularly therefrom, and this I shall continue to do in subsequent seasons, by way of showing whether or not there is any ground for the generally received opinion that river-water is inferior to that of wells for the irrigation of poppy-crops; manures being of course entirely withheld from the plots under experimentation. As regards the present season, the crop was in all respects much inferior to that on the adjoining plot, No. 13; the same variety of seed (*kalodantie* from Goruckpore) having been used on both. There was a considerable delay, however, in getting trenches cut for bringing water from the river (as the plot is 18 feet above the river level, and a portion of the cut was through a deep layer of kankur, *i.e.*, hard concretionary limestone) and the sowing up of this plot was some 16 days later than the other, which was of course a disadvantage, and no doubt affects considerably the results, which were as follows:—The tabular statement shows that the total weight of plants in the present plot was 124 seers, against 278 seers on plot 13. Again, the total produce of seed was 30 seers 2 chittacks, against 47 seers 13 chittacks; of which 4 seers and 7 seers 8 chittacks were respectively the produce of the more copious drug-yielding capsules. In the opium produce we find still more marked contrasts; the river irrigated plot only yielding 15 chittacks, whereas that irrigated from the well, yielded 3 seers 14 chittacks. Now, making all due allowance for the later sowing of the former plot, I do think we have still grounds for the belief that river-water is less fertilizing than that from certain wells. In my next season's experiments, however, I shall be careful to have both the above experimental plots sown at the same time.

14. This plot comprises about $7\frac{1}{2}$ cottahs, of which, however, only some 2 cottahs were really under cultivation; the seeds on the remaining having utterly failed, and the season too far gone for re-sowing. That which did succeed was of the Lukria variety of the Malwa poppy, and sent to me by the Sub-Deputy Opium Agent of Gya. The seeds, prior to sowing, were steeped for 24 hours in water, then dried in quicklime, and at once sown on the 28th of November; they had germinated very freely by the 1st of December. The total

weight of plants was 33 seers, of which 9 seers were fairly copious drug-producers; seed produce 6 seers 9 chittacks, and of this only 17 chittacks were the produce of the more copious drug-yielding capsules. Opium 9 seers 1 chittack: a very fair out-turn for the yet imperfectly habituated Malwa poppy in Behar.

15. This plot consists of about $5\frac{1}{2}$ cottahs. All was sown with variously treated seeds of the Malwa varieties on the 3rd and 4th of December, but the seeds failed on all but one small portion (comprising about 2 cottahs). The whole of the plot had a liberal application of buffalo-dung in the beginning of November. It was sown with seed of the *Lukria* poppy, this having been previously steeped in ammoniac sulphate of iron, ($\frac{1}{2}$ oz. to a pint of water) for 24 hours, and dried with powdered charcoal; germination was free and regular by the 12th of December. The plant progressed favorably, and when harvested weighed in the air-dry state 36 seers. The total produce of seeds was 7 seers 8 chittacks, and the produce of opium was $12\frac{1}{4}$ chittacks, considerably the most productive of any of the experiments with Malwa poppy. I attribute this, however, to the plant being much more closely grown than in any of the other plots, and it having also a southerly shelter from the jail walls, which I think was an advantage to it.

16. This plot comprises about 5 cottahs. On the 14th of November after a half-trenching, it had an application of 2 maunds castor-oil-cake, 2 maunds of sajee muttee, and 2 maunds of charcoal; this being well mixed on several occasions with the surface soil. Poppy-seeds of various kinds were sown on the 20th of November. One portion, (*a*) in plan, and about 2 cottahs in extent, was sown with Malwa poppy (*Lukria var.*), the seeds having been steeped in a solution of iron sulphate for 24 hours, dried with quicklime and sown. They germinated very freely, and gave rise to a very regular and, upon the whole, vigorous crop. The total weight of air-dried plant was 36 seers; seed produce, $7\frac{1}{4}$ seers, and opium, 1 seer 2 chittacks. On portion (*b*) of plan, the above seeds were again used, but in this case steeped in water only and dried with quicklime. Strangely enough, scarcely a single seed germinated (though similarly treated seeds germinated freely enough on other plots), and as the season was far advanced before I gave up hope of their doing so, I did not resow the part. On portion (*c*) on plan, comprising about $1\frac{1}{2}$ cottahs, I made sowings of the several samples noted in the tabular statement given on page 29 of my last general report, dated the 16th of May 1873. In the following tabular statement, the results of this season's sowings are given, and for the sake of comparison I have added a column from last year's table, showing the weight of 1,000 air-dried seeds of each. Cols. 7 and 8 shows the size of the seeds of col. 4, and gives the proportions retained by sieves of the twenty-fourth and thirtieth of an inch mesh.

		1	2		3		4		5		6		7		8	
Number.		No. of plants.	Total weight air-dried.		Total weight of capsules.		Total weight of seeds.		No. of seeds.	Weight in grains.	No. of seeds.	Weight in grains.	Seeds retained by a twenty-fourth of an inch sieve.		Seeds retained by a thirtieth of an inch sieve.	
			Srs.	Chs.	Srs.	Chs.	Srs.	Chs.					Chs.	Ks.	Chs.	Ks.
1	Small tapped capsules ...	135	2	0	0	12	0	9	1,000	5·12	1,000	5·00	3	1	5	3
2	Small untapped do. ...	128	1	8	0	10	0	6	...	5·25	...	5·00	2	2	3	2
3	Small tapped do. ...	149	1	14	1	0	0	10	...	5·25	...	5·50	4	1	5	3
4	Small untapped do. ...	169	1	12	0	10	0	6	...	6·00	...	5·25	2	3	3	1
5	Large tapped do. ...	135	2	0	0	10	0	7	...	5·50	...	5·00	3	3	3	1
6	Large untapped do. ...	246	2	12	1	6	0	11	...	6·15	...	6·00	4	1	6	3
7	Uggarya var. tapped capsules	235	2	...	0	14	0	13	...	5·75	...	5·00	4	3	8	1
8	Do. do. untapped do ...	308	2	8	1	0	0	9	...	5·25	...	4·00	3	1	5	3
9	Large untapped capsules ...	173	3	0	1	4	0	9	...	6·15	...	...	3	2	5	2
10	Large do. do. ...	278	3	4	1	12	1	0	...	6·00	...	...	5	3	10	1
11	Small do. do. ...	180	2	4	1	4	0	12	...	5·00	...	3·00	4	1	7	3
12	Malwa var. crossed with local untapped capsules ...	221	3	0	1	4	0	10	...	6·00	...	...	4	1	5	3
13	Malwa tapped do. ...	150	2	8	1	0	0	12	...	6·25	...	6·00	4	2	7	2
14	Malwa untapped capsules ...	200	2	12	1	6	0	13	...	6·15	...	5·50	4	2	8	2

The number of plants given in col. 1 is in each sample the produce of 14 square feet; it will be seen by col. 2 how indefinitely they vary in weight, though all similarly treated; and again, in the proportion of seed to weight of capsules. Again, we in general find that capsules containing

a small number of seed, produce them of lower specific gravity: though this is not by any means borne out by the above tabular statement; indeed, so indefinite are the variations, that I have given up the idea of reducing them to any definite rule. It has plainly nothing to do with the vigour or weight of plant, the size of capsule, number or quantity of seed contained, but on the other hand, has very probably relation to the conditional development of the embryo-vesicles at the period of impregnation.

17. This plot comprises upwards of $6\frac{3}{4}$ cottahs. On the 22nd of November it had a liberal application of cowdung with 4 maunds (in equal quantities) of powdered charcoal and castor-oil-cake. I had reserved for a portion of this plot a few packets of seeds which I had last year taken from plants less or more seriously affected with poppy mould. 1*st*. seeds from Jaloun: taken from plants very seriously affected with the latter, *Peronospora arborescens*. Prior to sowing the seeds, I steeped them for 24 hours in a solution of copper sulphate, dried them in quicklime, and then subjected them to a stream of water in a fine sieve, meshes the thirty-sixth of an inch; thus thinking that I would wash off any mould which might yet be attached to the seeds. I tried also steeps of soda sulphate; the subsequent treatment being similar to the above. Others I simply subjected to prolonged washing on the sieve, and a fourth portion was sown untreated. All the seeds germinated very freely, but to my surprise, towards the close of January the poppy mould made its appearance simultaneously on all the plants: those from the alkaline steeped seeds, the simply washed, and the wholly untreated were alike affected with the mould. I repeated the experiment with several other packets, trying all sorts of steeps which I thought likely to answer the end in view, and in every case prior to sowing the seeds, I subjected them to a thorough washing on a fine sieve. All, however, was unavailing, in every case, seeds from affected plants reproduced others with the mould affection. Again, in plots sown with seeds from my last season's experimental garden, and on which I had observed no mould whatever, it was nevertheless prevalent on this season's crop. With a view to arrest its spread I dusted the plants with sulphur, sulphur and charcoal, various alkaline salts, with the addition of lime and charcoal, but none had the slightest effect. The mould ran its periodic course, full details of which will subsequently be given, in treating of the more serious and prevalent diseases and injuries to which the poppy is subject. The remaining portion of the plot was sown with various seeds from tapped and untapped capsules, but as there were no noteworthy differences in the results, it is not worth while giving them in detail. The total produce of air-dried plants was 149 seers, only 46 seers of which were fairly copious drug-producing plants; the produce of seeds was $30\frac{1}{2}$ seers, of which about 6 seers were yielded by the best capsules. Opium, 11 chittacks.

18. I append a tabular statement of the results of the foregoing experiments, which are thus arranged:—Col. 1 indicates the number of plot; col. 2 the number of the plants in one of the most uniform and best filled compartments: the area being a square of 9 feet; col. 3 gives the weight of plants in an air-dried state; col. 4 the height of the plants in inches; while in col. 5 we have the weight of seed in chittacks and kanchas. In col. 6 the total weight of plant (air-dried) produced in each plot is given; and in col. 7 we have the weight of plants with a minimum of four drug-yielding incisions. A glance at cols. 6 and 7 shows how very largely the poor exceed the more copious drug-producing plants. Cols. 8, 9, and 10 dispose of the capsules under different grades of fertility: thus, col. 8 gives those with a minimum of five drug-yielding incisions; col. 9 gives those with four incisions; while col. 10 includes all the poor drug-yielders, having a maximum of three incisions. Again, cols. 11, 12, and 13 give respectively the weight of seed produced by the preceding three grades of capsules; col. 14 gives the number of drug collections from each plot; col. 15 the period over which these extended, and in col. 16 we have the weight of drug as collected from the capsules; while in col. 17 the weight of opium exceeding the standard consistence is given; col. 18 indicates the date on which the seed was sown, and col. 19 the number of times which each plot was irrigated.

PLAN

OF

DEEGAH EXPERIMENTAL GARDENS



Lithographed at the Surveyor General's Office, Calcutta, August 1874.

Deegah Outer Garden.

1	2	3		4	5		6		7		8		9		10		11		12		13		14	15		16		17		18		19
No. of plot.	No. of plts.	Sr.	Ch.	Inches.	Ch.	Ks.	Sr.	Ch.	Sr.	Ch.	Sr.	Ch.	Sr.	Ch.	Sr.	Ch.	Sr.	Ch.	Sr.	Ch.	Sr.	Ch.	Drug colln.	D. M. D. M.		Sr.	Ch.	Sr.	Ch.	D. M.		
1—4	160	...	6	8—32	1	...	300	...	35	...	5	10	2	4	79	12	2	13	1	...	39	11	8	23	2—18 3	5	4	2	9	19	10	10
5	191	1	6	20—41	5	2	142	...	40	...	6	4	6	4	86	8	3	2	3	4	42	10	8	24	2—20 3	4	10	2	½	26	10	9
6 *a*	169	...	10	12—36	2	3	40	...	5	...	2	...	1	3	16	4	1	2	...	10	6	...	8	23	2—16 3	.....	9½	.....	4½	26	10	9
6 *b*	166	1	4	20—40	5	3	38	12	10	...	5	...	2	6	17	6	2	12	1	3	8	11	8	23	2—16 3	1	2½	.....	7	26	10	9
7	288	1	4	10—36	5	2	42	12	4	...	1	...	...	12	16	...	.....	6	...	6	8	...	9	23	2—24 3	1	4½	.....	7	30	10	9
8 *a*	120	1	6	24—36	3	12	13	12	2	2	...	6	...	8	6	8	.....	1	...	3	2	12	7	26	2—17 3	.....	10	.....	4	30	10	9
8 *b*	140	...	12	18—23	1	2	14	8	1	12	...	7	1	4	6	12	.....	3	...	12	2	10	7	26	2—17 3	.....	7½	.....	8	30	10	9
8 *c*	120	...	3	4—17	...	2	14	12	.....	...	...	...	...	...	5	4	.....	...	...	...	2	12	4	26	2—10 3	.....	4½	.....	½	30	10	9
9	120	1	8	20—36	7	2	110	...	10	4	2	...	1	14	42	12	1	4	...	14	19	8	8	5	3—23 3	1	.....	.....	9½	29	11	8
10 *a*	145	2	4	30—46	7	2	165	...	24	...	12	8	8	10	61	...	7	4	4	8	32	10	9	22	2—18 3	4	12	2	11	6	11	8
10 *b*	136	1	14	24—40	6	1	54	12	6	4	2	2	1	14	20	12	.....	14	1	...	9	12	9	22	2—18 3	1	14	.....	12	6	11	8
10 *c*	118	...	12	10—30	1	0	21	...	.....	...	...	...	2	12	8	4	.....	...	1	4	3	8	7	22	2—14 3	.....	9½	.....	4½	7	11	8
11	136	1	12	24—36	5	2	145	...	18	...	8	...	1	6	19	4	¼	5	...	12	9	15	7	7	3—23 3	5	4	2	9	20	11	7
12 *a*	151	2	3	30—50	7	...	201	...	19	...	4	...	1	8	42	...	1	...	...	4	14	...	5	22	3—17 3	1	6½	1	.....	15	11	8
12 *b*	125	2	...	24—48	6	4	262	...	23	...	8	4	3	...	64	...	5	...	1	8	36	...	7	22	3—20 3	¼	4½	3	11½	15	11	8
13 *a*	64	1	...	24—40	3	...	125	...	11	...	5	...	3	12	56	...	3	...	1	...	28	¼	10	2	3—23 3	2	6	1	13	26	11	7
13 *b*	87	1	6	24—40	5	...	163	...	16	...	8	¼	7	...	60	...	¼	8	3	6	34	10	10	2	3—23 3	4	8	2	1	26	11	7
14 *a*	185	2	...	36—59	8	2	135	12	24	...	12	8	6	12	20	...	6	...	3	12	9	14	8	½	3—21 3	3	9	1	3	17	11	8
14 *b*	154	1	10	24—40	6	...	27	...	6	...	1	...	2	8	9	...	.....	9	...	11	4	8	10	18	2—17 3	1	.....	.....	5	17	11	8
15 *a*	100	...	12	30—42	2	...	51	...	7	8	3	...	1	8	14	...	1	12	...	11	8	...	11	4	3—25 3	1	14	.....	12½	29	11	7
15 *b*	120	...	15	29—52	3	...	80	...	21	...	6	4	10	...	15	...	3	4	5	4	8	...	11	4	3—25 3	1	12	.....	15	29	11	7
15 *c*	155	...	12	20—40	3	...	117	...	35	...	11	8	15	8	32	...	8	...	9	8	15	...	11	4	3—25 3	3	4	1	9	29	11	7
15 *d*	124	...	15	30—42	2	...	106	...	20	8	5	8	16	4	28	...	3	...	9	...	15	...	11	4	3—25 3	2	6	1	7	29	11	7
16	104	1	4	24—40	5	...	124	...	20	...	6	8	6	12	45	...	3	2	4	...	23	...	8	8	3—24 3	1	12	.....	15	12	12	6
17	128	1	8	24—40	5	3	33	9	9	...	2	...	1	...	9	...	1	1	...	8	5	...	9	1	3—22 3	1	4	.....	9½	28	11	7
18	76	...	15	20—40	3	...	36	...	5	4	1	8	2	4	10	...	.....	12	1	4	5	8	7	23	2—22 3	1	14	.....	12½	3	12	6
19 *a*	131	1	4	30—48	5	...	36	...	5	12	1	¼	½	...	9	...	.....	12	1	8	5	...	7	4	3—25 3	2	6	1	2	20	11	7
20	146	1	8	24—40	5	2	149	...	46	...	10	6	4	8	68	...	5	12	2	...	36	12	8	1	3—22 3	1	10	.....	11	12	12	6
							2,748	9	425	6	132	3	115	...	847	6	71	10	53	12	436	14				62	14¾	31	15¾			

SECTION III.

DEEGAH — LANDS ENCLOSED BY THE JAIL WALL.

Plots.—1 and 2. These plots being sown with the same variety of seed, and in all respects similarly treated, I need not treat them separately: they comprise about 25¼ cottahs. Prior to the final preparations of ploughing and preparing for sowing the poppy-seeds, the present and all succeeding plots were half-trenched, the *first* to *fifth* plots having in addition an application of 40 maunds of lime. Plots *first* and *second* were sown with poppy-seeds on the 15th and 16th of October; these were the produce of large untapped capsules grown in the seed garden under me at Goolzarbagh in 1872 and 73, the seed having been originally received from the Benares Agency. Though the crop was by no means full or uniform, the plant was generally very vigorous and promised to be fairly prolific. On the 1st of December, I observed the poppy mould on the lower leaves of a few of the plants: it was nowhere prevalent however, and I pulled up the few plants affected with it. I could find it on none of the plants in the adjoining plots. In the early part of January it became very prevalent, and indeed, by the 10th of that month it was difficult to find a single plant which had not its lower leaves less or more affected. So it was on all the October sown crops. I became quite alarmed at its prevalence, and this the more especially as we had then indications of rain which I thought (mistakingly as I afterwards learned) would afford conditions still more favorable to its rapid extension. I at once set a large party to work in picking off all affected leaves, much to the horrification of my sirdar, who told me that the plants after such treatment would give little or no opium. I however continued the work, and thus went over the plots numbered 1 to 7 on the plan of the inside lands, collecting a very large heap of affected leaves: it proved, however, 'labor lost.' On the opposite side of those plots, there were others similarly affected and sown about the same time; these I left untouched, and found that they were not a whit more injured than those from which I had picked all affected leaves. I soon observed that its extension was limited by the periodic development of the plant. Thus from the seed leaves to the stage at which the plant begins to form a distinct stem is a period of almost continuous growth; from that to the formation of the nascent flower bud, we have another, a third in its full development, completing the vegetative process. I found the extension of the mould similarly limited, thus while all the root and the fully matured leaves of the young poppy were more or less covered with the poppy mould, I found no trace of it on the developing cauline leaves, and so again was its extension limited by the next serial development of leaves, while the upper series were only affected when the vegetative process had been fully completed, fertilization affected, and the capsule less or more fully developed. Indeed, in a few experiments I found that while I sustained the vegetative process of a few plants by continuedly cutting out the young flower buds, the successive lateral shoots were always similarly unaffected until their leaves reached a certain stage of development. It is important to observe that in no case have I observed poppy mould on a developing leaf. In its periodic development, or at least its limitation to the fully mature leaves, the poppy mould appears to be altogether different from its ally, the potato mould. This, however, with a detailed notice of the extension of the poppy mould and the conditions apparently most favorable to it, will form the subject of a subsequent part of this report. The total weight of the air-dried plant on this plot was 933¼ seers, and of this 262¾ seers comprised all the more copious drug-producing plants; the produce of good seed was 33 seers, whereas that from the poor drug-yielding capsules was 129 seers, 10 chittacks. The yield of opium was only 7 seers 8½ chittacks: a very poor outturn indeed, considering as is ordinarily done, the mere vigour of the plant; this, however, as I shall subsequently show, is really no index whatever to the drug-producing capabilities of the plant. I should also notice here that there were several well marked varieties of poppy in the above crop, though the majority consisted of two only, one with roundish ovate glaucous capsules, and the other with oblong non-glaucous capsules; the latter generally was the more productive.

3. This plot comprises one beegha of 27,225 square feet. The seeds used on this plot were the produce of the small sized and lanced capsules of a plot in my last season's experimental garden at Goolzarbagh ; they were sown on the 18th of October. The crop had many blank patches, but the plant was generally vigorous; the total weight being 497¾ seers, and of this the more copious drug-yielding plants formed 159 seers. The produce of opium was 4 seers 11½ chittacks ; so that taking into comparison the total weight of plants in this and the two preceding plots, we find that the latter, even though the produce of the smaller sized capsules, has afforded a relatively superior drug-producing crop than the seeds of the large untapped capsules. I should note, however, that amongst the inferior drug-producing plants there was a very large percentage of mere wildings which really yielded little or no drug. The same variety of seed was used on each of the above plots.

4. Plot, one beegha of 27,225 square feet. Seeds were sown on the 19th of October and were the produce of unlanced capsules in the experimental garden at Goolzarbagh. Though there were considerable blanks in the plot from inefficient preparation of the soil, the plant, as will be seen by reference to my tabular statement, was fairly vigorous. Though of untapped capsules, the crop had more than a half of fairly copious drug-producing plants, and afforded a total of 6¼ seers of opium, thus exceeding considerably the produce of the preceding plots. It was wholly due, however, to the superior drug-producing power of the variety, and we shall see from the results of the following plots from the same seed, but of regularly lanced capsules, that in this instance also unlanced capsules have given origin to a less copious drug-producing race.

5. Plot, one beegha of 27,225 square feet. Poppy-seeds were sown on this plot on the 21st of October; they were the produce of lanced capsules of the preceding variety and grown in the Goolzarbagh experimental garden. The crop was far from full as will at once be evident by a comparative calculation of the total weight of plant borne in a selected compartment of 9 square feet (*vide* col. 2 of tabular statement) and the total produce as shown in cols. 5 and 6. It will be seen from the comparison that it would have required at least 4½ times more plants to have made a fairly uniform crop.—To save repetition I beg that the tabular statement may be consulted in all cases where it is desirable to ascertain the relative fertility of different plots, it being by no means sufficient to know the mere area of the respective plots.—On the present plot the proportion of poor to fairly copious drug-producing plants was nearly as two to one, and in the produce of seed the former exceeded the latter by more than four to one. The yield of opium (and this a drug of high consistence) was 10 seers 3½ chittacks, thus exceeding the produce of the same area in the preceding plot by about 4 seers. This is important, as showing how, under similar conditions, a variety deteriorates as a drug-producer by discontinuing drug-extraction for a single season. In treating subsequently the varieties of the opium-yielding poppy, I shall show how superior in this respect, the cultivated are to the feral forms.

6. This plot also comprises one beegha of 27,225 square feet, and was sown up on the 28th of October with seeds from lanced capsules of the same variety as Nos. 1, 2 and 3. The crop was very fair, but unfortunately there was a very large proportion of poor drug-producing plants. Thus, of the total produce of air-dried plants (614 seers) only 110 seers, or about one-sixth, were fairly copious drug-producers. With such disproportionate averages, we can easily see how seriously a poppy crop may be deteriorated even by the thinning out of the plant, as I have reason to believe that as a rule the more copious drug-producers are less vigorous in habit than the other, and are thus more likely to be 'plucked' in the process of "thinning" I note this as the crop (vegetatively) was much heavier than that from the unlanced capsule-seed of No. 4. In this instance, we find the proportion of the poor to the more copious drug-producing plants as about 5 to 1; while the proportion of inferior to good seeds (this always having reference to the drug-producing qualities of the capsules) is as 7 to 1. The yield of opium w as 5 seers 10 chittacks, or about

half that of the lanced capsule seeds of No. 5, and under the unlanced capsule seeds of No. 4; though considerably exceeding both in the actual weight of plant, as will be seen by a comparative reference to my tabular statement.

7. This plot (comprising one beegha of 27,225 square feet) was sown on the 26th of October with seed from small sized unlanced capsules: these being the produce of the same plot in the Goolzarbagh experimental garden as those of Nos. 1 and 2. As compared with the results of plot 3, it will be observed that while the total weight of plant on both was very similar, there is a marked contrast in the proportions of copious drug-yielding plants; plot 7 yielding only 67 seers of such, whereas plot 3 shows 159 seers. Again, in the produce of opium, we find that while both are very poorly productive, the latter has an excess of 13 chittacks. This, as I know from observation, is due to the excess of really all but sterile plants in the inferior class of plot 3. It is also noteworthy that the seeds from the smaller sized unlanced capsules give rise to a much less copious drug-producing crop than do those from the large sized capsules; this will be seen by comparing the results shown in lines one and seven of my tabular statement.

8. This plot, comprising one beegha, had on the 24th of October an application of 4 maunds of superphosphate of lime, with the same quantity of powdered charcoal. One half (*a*) of the plot was sown with seeds of the *kutylea* poppy, received from the Sub-Deputy Opium Agent of Shahabad, the other half (*b*) from seeds of the same variety received from the Sub-Deputy Opium Agent of Gya. Prior to sowing the seeds they were sifted on the thirtieth of an inch sieve; those only being sown which were retained upon it. Portion (*a*) was sown on the 14th of November and yielded a fair crop. The total weight of air-dried plants being 304 seers, of which 83 seers only were fairly copious drug-producers. Though the crop was a late one, the flow of drug was extremely free. The lancings for the first three times were on consecutive days, and on several subsequent occasions on alternate days, so that the total eleven lancings were made in a comparatively short period. The produce of crude drug was 6 seers $2\frac{1}{4}$ chittacks, and of opium, at a high consistence, $3\frac{1}{4}$ seers. The proportion of the prepared to the crude drug shows that there has been no deterioration occasioned by its more than usually rapid extraction. Portion (*b*) was sown with the Gya seeds on the 7th of December: certainly too late a period to expect a fair crop of poppy. The total weight of air-dried plant was 145 seers, of which 25 seers only were fairly copious drug-producers. In the $7\frac{3}{4}$ chittacks of opium we have also a minimum.

9. This plot was sown in part on the 31st of October. The seed used being the *kutylea var.* from Shahabad, and only the largest seeds or those retained by the twenty-fourth of an inch sieve were used. The crop was fairly full and the plant vigorous; the results are interesting. Thus the total weight of crop was $298\frac{1}{2}$ seers, and of this $34\frac{3}{4}$ seers were fairly copious drug-producers, less than one-third of which, $8\frac{1}{4}$ seers, were of the *kutylea var.* The remainder consisting of the common glaucous and non-glaucous capsuled varieties. The inferior class of plants presented very similar proportions: while nearly all were well marked from those on the adjoining plots by the large size of their capsules. What surprised me most, however, was the small proportion of the *kutylea* variety as compared with the others, as in all the other plots on which this seed had been used unsifted, the crop was surprisingly true to its kind. The results of this sifting with the larger meshed sieve, shows very clearly that the *kutylea var.*, must be the most vigorous or hardy of the varieties, in thus suppressing the others in the mixed sowings. The produce of opium was very fair, considering the time of sowing and the small proportion of fairly copious drug-producing plants; it was 3 seers $2\frac{1}{2}$ chittacks. As contrasting with the results of the above portion of this plot we may very briefly refer to those of the other portion 9 (*b*). In this case the seed was also the *kutytea var.* from Gya; that retained by a thirtieth of an inch seive being used. A very inferior crop was produced; the total weight of air-dried plant, $119\frac{3}{4}$ seers, and of this only 5 seers were fairly copious

drug-producers. The varieties were in nearly equal proportions, comprising the common glaucous and non-glaucous capsuled varieties and the *kutylea*. The produce of drug was only 1 seer $7\frac{1}{2}$ chittacks.

10. The half of this (*a*) was sown with a mixture of poppy and *cheena* seeds on the 12th of November. The crop was full and uniform, and the young poppy grew very vigorously under the light shade of the *cheena*. With regular thinnings I however, allowed both to attain maturity, and as the *cheena* did not, as I expected, reach this stage until the collection of drug from the poppy had been nearly completed, the result was that when the weather was at all windy, the brushing of the grass on the freshly lanced capsules caused some loss of drug. I thus certainly would not recommend mixed permanent sowings of *cheena* and poppy. The produce of the latter is fully given in my tabular statement. The remaining half of this plot was quite a failure. I attribute this, however, in part to the late sowing,—7th December—and my having been unable to water the soil sufficiently to enable the poppy-seed to germinate ere further irrigation was necessary. As the soil, however, got very dry, and none of the young poppy plants appearing, I re-watered the plot, but with no good effect, in as far as the latter was concerned. I do not think that there were over two dozens of poppy on the plot, but the flax seed (*Linum usitatissimum*) with which it was mixed, germinated freely and gave a fairly vigorous crop.

11 to 13 inclusive had the compartment ridges sown up with a few of the more commonly cultivated *Cruciferous* and *umbelliferous* plants, as Haline (*Lepidum sativum*), Shwet—Surcha (*Eruca sativa*), Dhunja (*Coriandrum sativum*), Agmoot (*Pimpinella involucrata*), Panmoori (*Fœniculum panmori*). The effects were not at all marked as compared with the others, but this need scarcely surprise us, considering the shelter afforded to the whole of my garden here by the jail wall: a circumstance which I quite overlooked in commencing the experiments. I repeat, however, that under exposed conditions, the cultivation of such plants as the above on the compartment ridges would certainly greatly benefit the young poppy. I cannot think that they would at all impoverish the soil for it, inasmuch as in the building up of their structure the two crops draw very differently on the inorganic constituents of the soil, and in fact rather tend to produce the well known good results of an alternation of crops. The results of the experiments are shown in the tabular statement, and it will be seen on comparing the total weight of plants, and the proportion of fairly copious drug-producers with the quantity of opium, that the results were very favorable. For example, we find that while plot 11*a* yielded a total of only 93 seers of plants, the yield of opium was 2 seers $6\frac{1}{2}$ chittacks; and again, 12*a*, with 62 seers of fairly copious drug-producing plants, yields 3 seers $15\frac{1}{2}$ chittacks; both plots comprising one-half beegha.

14 to 17*a* inclusive were sown up with poppy-seeds from the 6th to the 15th of December, but as the supply of water on this portion of the land was so scanty and the soil becoming dry and hard ere the seeds had germinated, the sowings completely failed, and the season was of course much too far gone to think of resowing.

17*b* comprises 10 cottahs. It was sown on the 29th of November with seeds of a variety of poppy called *Monaria*, and received from the Sub-Deputy Opium Agent of Monghyr. Plant of robust habit, though sparingly branched; the capsules oblong, ovate, and glaucous. The percentage of poor to the more copious drug-yielding plants was nearly as three to one; the estimate being formed on the relative weight of plant in the air-dried state. The percentage of capsules yielding drug to five incisions was very small, a larger number presenting four incisions, but the great majority bore no more than two. It was very disgusting to see plants in full vigour with all their parts green and immature, thus having the whole of their drug exhausted by two incisions. The total produce of seed was 32 seers 6 chittacks, and of this only 1 seer was yielded by the more copious drug-producers. Opium only $1\frac{1}{4}$ seer.

Plot 18*a*, comprising half a beegha, was sown on the 26th of November with seeds from Monghyr, sent as *kutylea* or thistle-leaved variety. They gave

rise to a very mixed crop; there being a large percentage of the common kinds with oblong and ovate-oblong, glaucous and non-glaucous capsules. The relative weight of poor to the more copious drug-yielding plants was exactly 8 to 1, but as the poor class of plants afforded very generally three full incisions, the produce of opium, $2\frac{1}{2}$ seers, was somewhat more than would have been anticipated by having regard only to the weight of the more copious drug-producers, or by comparing the results with those of the adjoining plots. Plot *b*. comprising also half a beegha was sown on the 23rd of November with seeds of a variety from Monghyr sent under the name of *Soogooa*. This variety is of a robust habit, freely branched, and bearing rather large sized, roundish, oblong, and glaucous capsules. The seed germinated very indifferently, and gave rise to a thin and irregular crop; the total weight of which, in the air-dried state, was only 97 seers. None of the capsules yielded to even five incisions and, but few to four; the remainder, however, very generally afforded three full incisions, and afforded about 1 seer of opium.

19. This was sown with seeds of two varieties from Tirhoot. The soil, a strong reddish colored sandy clay, with much concretionary limestone, became so dry and hard ere the seeds germinated, that all had to be re-watered; very few ever germinated, and the plots were re-sown on the 7th of December with seeds of small unlanced capsules. These gave rise to a light, but upon the whole, a regular crop; the total weight of which was 242 seers; all, however, very poor drug-yielders. A small proportion of the capsules had, as a maximum, four incisions only, the remainder three and two; the total drug produce was but 3 seers $9\frac{1}{2}$ chittacks.

20*a*, comprising half a beegha, was sown on the 13th of November with the Telpah poppy, sent to me by the Sub-Deputy Opium Agent of Bettiah. The plant presents no distinguishing characters from that in general cultivation; the capsules are of an oblong-ovate shape and glaucous. The crop was rather thin; the total weight of air-dried plant being only 180 seers, and of this 23 seers, or about one-eighth, comprised the whole of the fairly copious drug-producers. Again, amongst the inferior plants there were very many which afforded but two incisions (though the capsules were of the ordinary size), and the produce of opium was thus somewhat under 3 seers. *b*. comprising the remaining portion of this plot, was sown with seeds sent me by the Sub-Deputy Opium Agent of Gya. They were sent under no local name, and the plant as it grew up presented no distinguishing characters; the capsules were of medium size, ovate, oblong, and glaucous. The total weight of air-dried plant was 139 seers, of which about one-eighth were fairly copious drug-producers, and the yield of opium thus amounted to only 1 seer $3\frac{1}{2}$ chittacks.

21 to 24*a* were all sown with seeds sent me from the Gya division. They consisted of three well-marked varieties, one with flattish or roundish, oblate, glaucous capsules, a second with oblong-ovate capsules, and a third with oblong, non-glaucous capsules. Seed-sowing was completed between the 1st and 9th November. The most productive of the lot was that of 24*a*, and this, as will be seen by a reference to the tabular statement, though having a fair proportion—about one-third—of the better class of plants scarcely yielded 3 seers of opium. 24*b* was sown on the 30th of October with seeds from the Alleegunge division. The crop was rather thin, and the proportion of the poor to the more copious drug-yielding plant was nearly as four to one. The produce of opium being 2 seers.

25. The portion marked *a* on plan was sown on the 29th of October with seeds from the Alleegunge division. The seed germinated very freely and produced a full and very uniform crop. As the flowers dropped off, however, and the capsules began to mature, it was found to comprise at least three well-marked varieties; first, one with oblong-ovate capsules of a dull greenish color; second, one with roundish-oblong and glaucous capsules; and the third, that known as *kalodantie*, and well distinguished by the stalks of the plant acquiring a purply-black hue as the plant attains maturity. The total weight of the crop was 325 seers, and of this $71\frac{1}{4}$ seers comprised all the more

copious drug-producing plants ; thus 31¾ seers of the first variety, 25 seers of the second, and 14½ seers of the third. The first variety also produced considerably the highest proportion of good capsules, as will be seen by a comparison of the results shown in my tabular statement. The produce of opium was 6 seers 1¼ chittacks. Portion *b* of this plot was also sown with seeds from the Alleegunge division ; the variety did not differ from that in general cultivation, having glaucous capsules of a roundish-ovate shape. The crop was upon the whole very uniform ; the total weight of air-dried plant amounting to 238 seers. The proportion of really copious drug-yielding plants however, was small, as compared with the returns of the preceding plot, amounting in this case to 28 seers only, which is as 8½ to 1 ; and the result was that I got little more than one-third of the quantity of opium.

26. The portion of this plot marked *a* on the plan was sown on the 27th of October with seeds from the Patna division, and of the variety locally known as *teylea*. It is well distinguished by its medium-sized capsules of an ovate-oblong shape and dull greenish color. The total produce of air-dried plant was 281 seers, of which 106 seers were fairly copious drug-producers. I expected a high outturn from this plot ; but in this I was disappointed, as I only got 3½ seers of opium. This was owing to more than one-half of the first-class plants affording only four incisions, while the inferior class proved extremely unproductive. Portion *b* of this plot was sown on the 28th of October with the *kutylea* or cut-leaved variety from the Motiharee division. The seeds germinated well and produced a full and regular crop ; the total produce of which was 237 seers, comprising, however, only 70 seers of fairly copious drug-producers. The proportion, however, of capsules on the first class plants which had yielded to five incisions proved very small (as will be seen on a reference to the tabular statement), and the opium (being thus chiefly the produce of capsules with from four to two lancings) was but a fraction more than 2 seers.

27.—This, as shown in the plan, had five sub-divisions ; thus, *a* comprising about 12¼ cottahs, was sown on the 24th of October with seeds of a variety of poppy locally known as *seelhetia* and sent me by the Sub-Deputy Opium Agent of Patna. It forms a robust, freely branched plant and well distinguished by its large roundish-oblate and glaucous capsules. The soil varied considerably on this plot, and there were large patches of it on which the seed utterly failed, though sown repeatedly—three and four times. The crop was thus very irregular, though robust, weighing in the air-dried state 339 seers, of which nearly the half were fairly copious drug-producing plants, and the quantity of opium was 3 seers 13 chittacks. I was much surprised with the variation in the color of the drug as it exuded from this crop, the individual plants presenting no distinguishing character whatever. The large proportion of the plants yielded a drug varying in shades of pinky-red, while others varied from a dirty-grey to a chalky and milky-white. I marked several of these plants and found that on each incision they yielded a similarly colored drug. I should state, however, that the drug only acquires these several shades on exposure to the air. It is interesting to note the extreme sensitiveness of the drug in thus acquiring the various shades of pink ; the oxidation is momentary, and the juice would appear to exude from the vessels of those shades, but on examining them we find their contents colorless. *b*. This portion, comprising less than 4 cottahs, was sown on the 24th October ; the variety of seed used being that known as *monaria* and sent me by the Sub-Deputy Opium Agent of Patna. The crop as it grew up proved to consist in about equal numbers of two varieties, one (*monaria*) with oblong-glaucous capsules, and the other (*teylea*) of ovate-oblong capsules of a dull green color. The crop, though full and regular throughout, was very light, from being much overshadowed by a large *Debdar* tree. The total weight of plant was 81 seers, of which only 17 seers or little more than one-fifth were at all copious drug-producers ; the yield of opium was only 15¼ chittacks. *c*. This portion was sown on the 24th of October with seeds of a variety sent me by the Patna Sub-Deputy Opium Agent under the name of *Huldee-dana*. I know not why it should be so called,

as the seeds differ not in color from the ordinary varieties, and the crop as it reached maturity presented in about equal proportions the varieties noted under *b*. They were, however, even worse drug-producers than those, yielding only $15\frac{1}{2}$ chittacks of opium, though the plot was larger by about $\frac{3}{4}$ths of a cottah and bore an excess of 15 seers of air-dried plants.—*d*. This portion comprising about $9\frac{3}{4}$ cottahs, was sown on the 24th of October with seeds of the *monaria* variety sent me by the Sub-Deputy Opium Agent of Patna. The crop, with the exception of a few blank patches, was, upon the whole, full and regular; the total weight of air-dried plants was 233 seers, 80 seers, or over one third of which were fairly copious drug-producers; the four lanced capsules and those with five lancings and upwards being nearly in equal proportions. The weight of opium was $3\frac{1}{2}$ seers.—*e*. This portion, comprising about $3\frac{1}{2}$ cottahs, was sown on the 24th of October with seeds sent me as the *kutylea var.* by the Sub-Deputy Opium Agent of Patna. Scarcely a single plant, however, of this variety appeared; the crop consisting in about equal proportions of that known as *teylea*, and another common kind with medium sized, roundish-ovate and glaucous capsules. They proved to be a poor and unproductive set, as out of a total of 164 seers of air-dried plant, scarcely more than one-ninth were fairly copious drug-producers, and the quantity of drug yielded was only $13\frac{1}{4}$ chittacks.

28. The division marked *a* on plan, and comprising upwards of $9\frac{1}{2}$ cottahs, was sown on the 20th of October with seeds of the *bujree* poppy, sent me by the Sub-Deputy Opium Agent of Shahabad. The seed germinated very freely and afforded a very uniform crop. My remarks on it are as follows:—"plant healthy, though rather slender; from 36 to 48 inches high, sparingly branched, and bearing from 2 to 6 capsules of an ovate-oblong shape, glaucous, and on an average about 2 inches long by $1\frac{1}{2}$ inches broad. The total weight of air-dried plants was 209 seers, of which $86\frac{1}{2}$ seers were fairly copious drug-yielding plants, the capsules, though of medium size, having afforded from 5 to 10 good incisions. The weight of opium was 3 seers $1\frac{1}{4}$ chittacks.—*b*. comprising about $12\frac{1}{2}$ cottahs, was sown on the 20th of October, with seeds of the *teylea* variety from Shahabad. The seed germinated very well, but from the poorness of the soil the crop was very light; the total weight of air-dried plants being only $169\frac{3}{4}$ seers, and of this 41 seers, or about one-fourth, comprised the whole of the more copious drug-yielding plants, while the opium weighed only 2 seers.

29. The results of the several experiments on the lands inside the old jail are shown in the following tabular statement. The table is arranged similarly to that for the outside lands, as explained in paragraph 18 of *section* II.

Deegah — Enclosed Lands.

1	2	3		4	5		6		7		8		9		10		11		12		13		14	15	16		17		18	19
		Srs.	Ch.		Ch.	Kh.	Srs.	Ch.	Srs.	Ch.	Srs.	Ch.	Srs.	Ch.	Srs.	Ch.	Srs.	Ch.	Srs.	Ch.	Srs.	Ch.				Srs.	Ch.	Srs.	Ch.	
1—2	318	9	8	36—58	15	3	670	10	262	12	50	...	70	...	213	...	33	...	33	14	95	12	16	22 1—18 3	16	15	7	8½	16and17	10	16
3	184	7	4	36—58	9	2	338	12	159	...	32	...	63	8	143	12	16	8	27	14	74	4	16	27 1—20 3	8	7½	4	11½	18	10	15
4	210	6	4	30—50	8	12	356	...	186	...	48	...	47	8	116	4	24	...	24	4	48	8	12	3 2—20 3	11	5½	6	4	19	10	15
5	193	8	2	30—50	8	2	381	...	195	...	45	...	53	4	138	12	20	8	26	15	65	...	13	3 2—23 3	16	6½	10	8½	21	10	16
6	135	4	4	28—48	6	...	504	...	110	...	28	8	46	4	172	8	15	4	25	5	86	4	11	4 2—23 3	10	14½	5	10	23	10	13
7	189	4	12	20—50	6	8	322	...	67	...	18	12	26	...	94	12	10	8	14	15	58	...	13	4 2—22 3	6	11½	3	14	26	10	12
8 *a*	136	3	4	30—50	9	1	221	...	83	...	8	...	12	8	85	12	4	4	6	10	46	12	11	3 3—27 3	6	2¼	3	4	14	11	12
8 *b*	127	3	...	30—50	8	2	120	12	25	10	3	12	5	8	45	4	2	...	2	12	25	4	8	3 3—23 3	10	13	.....	7¼	7	12	10
9 *a*	211	3	2	30—48	9	2	263	12	34	12	9	12	18	6	95	4	5	...	11	...	43	11	12	20 2—28 3	4	6½	3	2¾	31	10	14
9 *b*	130	2	8	30—48	8	12	114	12	5	...	...	11	7	5	36	12	.....	5	2	12	18	13	10	20 2—20 3	3	9¾	1	7½	5	11	12
10	175	1	12	24—38	8	2	140	...	8	...	4	...	6	12	48	4	2	...	3	10	25	8	8	2 3—20 3	2	9½	1	12	12	11	12
11 *a*	165	2	...	26—42	6	4	81	...	12	...	2	8	5	8	38	8	1	...	2	15	20	4	10	27 2—28 3	3	10½	2	6½	9	11	12
12 *a*	155	2	8	30—48	10	2	133	...	62	...	5	4	11	...	97	8	2	8	5	...	53	12	8	27 2—20 3	4	13½	3	15½	9	11	12
12 *b*	178	2	...	24—48	7	2	74	12	23	...	1	4	2	...	40	4	.....	10	1	3	20	12	6	7 3—22 3	2	8½	1	.....	9	11	12
13	194	2	..	30—46	8	2	59	12	18	...	5	...	3	12	22	12	2	6	2	2	11	5	7	10 3—28 3	1	14	1	1½	24	11	10
17	151	1	8	32—48	4	2	157	...	53	...	2	1	7	1	59	...	1	...	3	14	27	8	6	10 3—28 3	1	15	1	4¼	1	12	8
18 *a*	320	3	10	20—44	8	12	160	12	20	...	...	...	2	...	68	...	.....	...	...	14	36	5	8	10 3—28 3	3	5	2	8	26	11	10
18 *b*	180	2	4	30—48	7	2	80	...	17	...	...	...	1	...	55	8	.....	...	...	10	14	8	6	9 3—23 3	2	6	1	0¼	23	11	10
19 *a*	200	2	2	24—44	9	2	129	...	22	...	...	...	3	8	43	...	.....	...	1	12	22	4	6	9 3—23 3	2	10	1	10½	23	11	10
19 *b*	209	2	10	30—53	11	2	113	...	19	...	...	...	4	8	22	8	.....	...	2	9	13	12	6	27 2—23 3	2	15½	1	15	18	11	10
20 *a*	155	2	10	30—48	11	1	180	...	23	...	2	8	2	12	53	8	1	3	1	4	26	12	6	27 2—15 3	3	14	2	11	13	11	12
20 *b*	120	2	10	30—54	8	2	121	...	18	...	...	10	1	4	27	...	.....	5	...	14	13	...	7	27 2-23 3	2	8	1	3½	22	11	10
21 *a*	180	3	...	30—58	6	12	231	12	38	...	10	...	19	...	56	...	5	4	9	5	29	5	8	18 2—12 3	3	1	1	6	18	11	10
21 *b*	141	2	8	30—55	6	2	119	...	22	...	8	12	10	...	46	12	4	11	5	14	23	10	10	20 2—23 3	2	9½	1	8	18	11	10
22 *a*	246	2	...	36—58	5	8	125	...	69	12	23	...	11	12	63	...	10	12	6	5	27	8	8	18 2—12 3	5	13	2	7	18	11	10
22 *b*	253	1	14	36—58	5	...	230	...	19	...	5	...	10	14	56	12	3	1	6	4	30	2	11	17 2—23 3	2	6	.....	12	4	11	12
23 *a*	206	2	4	36—60	4	12	216	12	98	...	27	8	29	4	75	4	16	4	14	7	36	15	8	14 2—20 3	3	8	1	10¼	3	11	12
23 *b*	104	1	14	50—64	5	...	161	...	29	...	6	...	3	4	39	12	3	1	1	13	17	9	10	4 2—20 3	2	0½	.....	12	3	11	12
24 *a*	200	2	12	36—50	6	12	196	...	96	...	24	4	24	...	67	12	11	8	14	12	30	4	9	14 2—12 3	4	14½	2	13½	1	11	12
24 *b*	145	2	4	40—58	7	2	171	12	53	...	19	8	13	...	62	...	9	7	7	12	34	9	9	20 2—21 3	2	12	2	0	30	10	12
25 *a*	184	2	14	35—50	8	...	253	12	71	4	20	8	21	11	62	15	10	...	10	8	28	9	10	10 2—12 3	10	5	6	1¼	29	10	14
25 *b*	212	2	...	30—50	7	4	210	12	28	...	5	...	16	8	59	4	3	...	9	8	30	13	10	20 2—22 3	3	9½	2	9	29	10	14
26 *a*	169	2	12	30—60	8	12	175	12	106	...	20	12	12	8	33	8	10	10	6	6	16	15	12	4 2—12 3	4	13½	3	8	27	10	12
26 *b*	220	3	4	30—50	9	...	167	...	70	...	5	...	13	12	50	8	2	15	6	4	29	1	12	4 2—18 3	3	6½	2	0¼	28	10	12
27 *a*	192	2	10	30—56	9	...	187	...	152	...	34	8	16	4	48	...	17	4	8	9	21	...	10	4 2— 7 3	6	9	3	13	24	10	14
27 *b*	163	3	4	35—56	8	12	64	...	17	...	3	8	1	5	10	...	1	9	...	12	4	3	10	2 2— 9 3	1	8	.....	15¼	24	10	12
27 *c*	90	2	4	40—56	8	4	77	...	19	...	2	8	5	...	18	4	1	2	2	5	7	11	10	2 2— 9 3	1	3	.....	15½	24	10	12
27 *d*	130	3	12	46—60	9	4	153	...	80	...	8	8	10	...	31	...	3	12	6	1	11	1	12	4 2—10 3	5	7	3	8	24	10	14
27 *e*	216	3	4	30—47	8	2	145	...	19	...	2	15	6	15	21	3	1	12	3	2	10	6	9	14 2— 9 3	2	0½	.....	13¼	24	10	12
28 *a*	174	3	4	30—50	7	1	123	...	86	...	22	...	8	8	36	...	12	4	4	11	19	8	15	28 1— 8 3	5	8	3	1¼	20	10	16
28 *b*	220	2	...	20—40	5	4	128	12	41	...	8	8	8	8	36	...	4	2	3	15	16	8	10	4 2— 8 3	3	8½	2	0	20	10	14
							7,858	2	2,537	10	525	5	603	5	2,491	5	274	11	331	9	1,273	7			205	11¾	111	10¾			

SECTION IV.

THE VARIETIES OF THE INDIAN OPIUM-YIELDING POPPY.

1. Reflecting on the antiquity of the poppy as a cultivated plant for its drug-yielding qualities, it is not a little singular that we should yet have so few well characterized races, and of these not even one pure or selected variety to afford a crop of uniform and fairly copious drug-producing plants. I have every where observed that with a very large percentage of plants, the capsules of which have afforded from one to three incisions only, there are always a varying number of others with capsules affording 5 to 8, 10, and even 12 full incisions. I have been much struck with this, on a careful examination of the poppy generally during the past season, and I am convinced that by a careful selection of seeds from the most copious drug-producing plants only, (as explained in my letters to the Secretary to the Board of Revenue, and the Opium Agents of Behar and Benares, dated the 15th March last), that for every seer of opium now collected, 2 to 3 seers, and even more would be the produce of such crops. I should explain that what I aim at here involves no special selective improvements. We have the varieties ready to hand, and have but to select the productive from the unproductive. The process of selectively improving the best, or the most copious drug-producers of our present crops is quite another matter, though I see no reason to doubt that we may thus produce varieties as superior in their drug-producing qualities to the best of those now existing, as those, on the other hand, are superior to their wild progenitors. As my suggestions, however, on the above ~~plants~~ have apparently met with but indifferent acceptation, I shall patiently and confidently wait the results of my next season's experiments with seed of my own selection. As confirming my remarks, however, as to the large proportion the poor drug-producing plants bear to the others in the poppy fields now, I need only refer to my tabular statements as being a very fair index of such, inasmuch as they show the results of the best varieties which could be supplied me by the Opium Agent of Behar; and include seeds from each division of the Agency. I have also had in quantity, seeds of a variety of high repute, the *kalodantie* from the Benares Agency, which has proved even a less copious drug-producer than the generality of those supplied me from Behar.

2. I shall now briefly describe the several varieties of the opium-poppy which I have for next season's experiments.

P. somniferum; stem from 2 to 5 feet high, simple or divided, smooth, rarely setigerous; leaves oblong or ovate, toothed and lobed, rarely pinnately-lobed; from 4 to 15 inches long by $1\frac{1}{2}$ to $9\frac{1}{2}$ inches broad; flower from 2 to 8 inches in diameter, white to various shades of purple to scarlet; petals entire, toothed to deeply fringed; capsule ovate to oblong, or roundish to oblate, from 12 to 33 lines long, with like variations in diameter; stigmas 3 to 16, radiating, sessile, and crowning the top of the ovary; seeds whitish or purply-black. There are two well marked varieties, one, *P. somniferum nigrum*, with roundish ovate capsules, opening by holes under the stigma (*vide* figure 6, plate 2), and seeds of a purply-black color; this appears to be the normal wild form. The other, *P. somniferum album*, has whitish seeds and usually ovate-oblong capsules which do not open by holes under the stigmas, thus evincing the more direct relationship to the cultivated opium-yielding varieties. It would at least appear to be the progenitor of those cultivated in the Agencies of the Indian Government; while, on the other hand, the Malwa poppy with its very generally purply or scarlet flowers, fringed petals, and in certain varieties, purply-black seeds, the dusty-yellowish-white color of the exuding juice, brownish colored opium, with the morphia in excess of narcotine, rather suggests a descent from the other variety, *P. somniferum nigrum.* In plate 1, I have figured three degenerate varieties of poppy which occasionally spring up in our fields; figure 1 is the most common, and with the exception of the reddish colored flowers, approaches very closely to the wild *P. S. Album;* figure 2 differs considerably in the sharp outline, deep, and serratured lobes of the leaf; figure 3 is quite an

abnormal form; stems simple or divided, from 30 to 40 inches high; the leaves ovate, or ovate-oblong, 10 to 13 inches long by $3\frac{1}{2}$ to 5 inches broad; the flowers solitary, small, streaked with dull green and red; the petals much crumpled and never expanding fully from the long persistent sepals, which bursting at the base, only form a cap to the expanding petals; the latter are about 2 inches long by 1 inch broad; stamens from 140 to 160, frequently with ovule-bearing anthers; pollen-grains from 500 to 550th of an inch, ovate; capsule globose, smooth, opening by holes under the stigma, which is from 11 to 13 rayed; seeds purply-black. This variety is much more frequent on plots where the Malwa kinds have been grown than on those of the local sorts. If not carefully eradicated as soon as its flowers appear, or at least prior to the ripening of its seeds, it will soon become a most troublesome weed. It is of that variety which has pores under the stigma for the discharge of the seeds, and these retaining their vitality in the soil spring up simultaneously with the following season's crop, and as the two cannot be distinguished when young, it may thus soon form a large and very unproductive part of the crop. It yields a very small quantity of drug; the capsules as a rule do not afford more than two incisions, and to these even the drug is very scanty. Two of the most experienced officers of the Behar Agency have assured me that the local white-flowered poppy has a great tendency to produce such varieties as the above on poor or worn-out soils. One of them further stated that seeds selected from such degenerate varieties and sown on rich soil would again revert to the normal form, and that in fact it was peculiar to the poorest soils. I was much struck with this, and determined at the earliest opportunity by direct experiment to confirm or disprove the statements. This much I observed last year, 1873, that the above varieties, though occurring on the most highly manured lands, were certainly much less prevalent than on the poorer soils with inferior crops. I, however, selected seed of the several varieties and sowed them on highly manured plots, and others which I knew were well worn out. The results were that in both cases the varieties were perfectly true to their kind, the only difference being that the crop of the manured plots was many times heavier than that of the unmanured. I think the real cause of the greater prevalence of such wildings on poor soils is that the crops on these, are as a rule, less carefully tended, and the former are thus more frequently allowed to disperse and naturalize themselves. As further confirming the view that mere sterility of soil does not particularly affect or induce the cultivated forms of poppy to revert to their wild type, I would refer to the results and remarks on the crops produced on one of the Deegah outside experimental plots—No. 8. In this case I observed none of those wild or abnormal forms; with very few exceptions all had white flowers, with faint purply streaks on the inside towards the base; all thus proving but dwarfed and stunted specimens of the common cultivated forms. In no case (and I very carefully looked to this) did I observe any tendency of the capsules to open by pores under the stigma for the discharge of the seeds as in the wild type. It is worth while describing one of these miniature forms of which I have given an illustration, plate 4, figure 3. The total height of plant was $3\frac{1}{2}$ inches, and weight while green, two grains; tap-root, 16 lines long, with a few fine fibres towards the apex; leaves 9, all more or less stem-clasping, oblong-ovate, obtusely crenated, from 4 to 9 lines long by 2 to 3 lines broad; sepals, 2, smooth, oval-oblong; margins scariose, 4 lines long by 2 lines broad; petals 4, obovate, entire; the larger pair, 6 lines long by 4 lines broad, the smaller, $5\frac{1}{2}$ lines by 2 broad; color, creamy-white with a few faint purply streaks and spots at the base; capsule obovate, obtusely 3 sided, smooth, of a pale glaucous green, (4 lines long by 2 lines in diameter) and crowned with 3 sessile radiating stigmas; stamens 4, one opposite each petal; filaments subulate with anthers one-twenty-fifth of an inch long by the one-fiftieth of an inch broad; pollen-grains varying from the 6-700th of an inch; all considerably smaller than those on the normally developed plants, which I find are from the 500-550th of an inch. I should also note that each anther had a large percentage of abortive pollen-grains. The capsule contained 27 fully developed seeds, of which 23 were

retained by a sieve with one-twenty-fourth of an inch meshes, and the remainder by the one-thirtieth of an inch. The seeds were thus of comparatively large size, as I have found that a very small percentage indeed of the seeds of the common poppy is retained by the twenty-fourth of an inch seive, the thirtieth being the general size. The weight of capsule with seed, 0·75 grains, and its capacity as measured by small shot was 10·50 grains. On the plate above referred to, figures 1, 2, 3, and 5 are illustrations of the Malwa poppy grown on similarly sterile soil, and in this case also I observed no greater variation in color of flower, &c., in the crop than in the case of crops from the same seed on highly manured lands; the difference alone lay in the reduction of stature and number of plants: all being merely miniature *fac similes* of the others, and of which for the sake of comparison, (*vide* Pl. III, figs. 6*a* and *b*, and figures 7*a* and *b*) I have given illustrations of fully developed poppy petals, also, transverse sections of capsules and front views of the stigmas of the local and Malwa poppies.

3. I may now briefly characterize a few of the best varieties of the local poppy which I have selected for next season's experiments. 1. *a. var.* capsules roundish, oblong, of a pale olive green color, about $2\frac{1}{2}$ inches long by $2\frac{1}{4}$ inches broad; juice a pale pinky red, each capsule affording from 6 to 10 full incisions. *Var. b.* capsules roundish, oblate, glaucous; juice of a pinkish color, copious and of high consistence, the capsules affording from 8 to 10, and even 12 full incisions. *Var. c. peduncles setigerous, i.e.*, beset with stiff hairs; capsules roundish-oblate, glaucous, of medium size; juice, pinky-white, copious, and of good consistence. *Var. d.* a well marked variety of robust habit and large oblate capsules, juice of a dull pinky white and very copious. I observed but a single plant of this variety in a crop raised from seeds sent me by the Sub-Deputy Opium Agent of Chota-Nagpore. *Var. e.* a variety of that well known as *kutylea* or thistle-leaved, but differing in having capsules of a dull olive green: the capsules of the ordinary variety being glaucous. *Var. f.* a well marked variety, with from 4 to 7 distinct stems (*vide* plate 4), and leaves similar to the common *kutylea*. I have also got seeds from similarly many-stemmed plants of the common glaucous and non-glaucous capsuled varieties, also the *kalodantie*, and one variety of the Malwa poppy. These I regard as important variations: they will enable us to dispense with fully half the quantity of seed at present required, while affording us plants less liable to suffer from winds than those which we now have. Besides these, I have carefully selected seeds from the most copious drug-producing plants of the common local varieties. My best seed in all cases being taken from the primary or central capsule. Again in the twin-capsuled peduncle figured on plate 2, we have a distinct, and as I think, what is likely to prove a very valuable variety, as facilitating the processes of lancing and drug-collection. I only picked up a very few specimens of this form; it is evidently as yet rare. I have also intercrossed in various ways the above varieties, so as to afford combinations of the best qualities. Thus, what with the carefully selected seed which I have of the common varieties, that of casual variation and various intercrosses, I do look forward with confidence to very important results from my next season's experiments.

4. The Malwa poppy differs considerably from the local poppy of both Agencies. It is at once distinguished by its more erect habit, simpler stem, sharply toothed leaves, of much thinner texture, and the usually red or purplish colored flowers with fringed petals, and rather large-sized oblong or ovate-oblong capsules, crowned with broad stigmatic rays. I append a description of the varieties which I cultivated during the past season. *Luckria* of erect habit, branching upwards, from 26 to 33 inches high, foliage, pale glaucous-green, oblong-ovate, the margins sinuous and toothed, from 7 to 11 inches long by 4 to $5\frac{1}{2}$ broad; flowers white, usually with a rosy or pink margin, fringed or entire; capsules ovate-oblong, of a dull glaucous green, about 2 inches long by $1\frac{3}{4}$ broad; stigmatic rays from 10 to 14; seeds white.

5. *Leela*, one of the most robust of the Malwa kinds; stem stout, sparingly branched upwards, from 36 to 48 inches high; leaves oblong, the margins lobed

and coarsely toothed, and of a pale glaucous-green, from 10 to 14 inches long by 5 to 6 inches broad; flowers generally white and deeply fringed, from 6 to 8 inches in diameter; capsules oblong or roundish-oblong, glaucous, about $2\frac{1}{2}$ inches long by 2 to $2\frac{1}{4}$ broad, and crowned with from 10 to 14 broad-spreading stigmatic rays.

6. *Gungajullee.*—A variety much resembling in habit the preceding, from 36 to 50 inches high, stem simple or nearly so; leaves oblong or ovate-oblong, with coarsely bidentate margins, from 8 to 11 inches long by 4 to 6 inches broad; flowers white, with or without rosy margins, usually fringed, and about 7 inches across; capsules about $2\frac{1}{2}$ inches long by $1\frac{3}{4}$ broad, oblong, more or less furrowed longitudinally: this is an undesirable character, and unless the lancers are careful in scarifying the ridges only, the drug is with difficulty collected.

Uggarya.—A variety of slender habit with nearly simple stems, from 30 to 40 inches high; leaves oblong to ovate-oblong, glaucous; margins sinuous and toothed, from 9 to 11 inches long by $3\frac{1}{2}$ to 5 inches broad; flowers red, with a purply stained base; the margins deeply fringed. This variety is extremely uniform in color of flowers; it is rare to see any with pale, pink, or white flowers; capsules elliptic, glaucous, about $2\frac{1}{2}$ inches long by $1\frac{3}{4}$ broad; crowned by 10 to 14 stigmatic rays, with broad scarious margins.—All the Malwa varieties of poppy have a dull milky-colored and thinnish juice which gradually changes to a pale smoky-brown, and is altogether much less copious than that of the local varieties. They are also of a less robust habit, suffering much even from light winds if they should chance to have been lately watered. I last season made a mistake in having them thinned out to the same distance as the local poppy, thus exposing them far too much, as they had but few, and those erect branches. Next season I shall grow the more slender varieties at four inches apart and the more robust at six inches.

SECTION V.

THE STRUCTURE AND FUNCTIONS OF THE CAPSULE OF THE OPIUM POPPY.

1. Under this head, while treating on the general structure of the capsule, I have specially in view the important object of illustrating the cause of the great variability in quantity of drug secreted by individual plants:—for example, while one individual bears capsules which will only yield drug to some two or three incisions, another individual (of no greater vegetative vigour) continues yielding to from six to eight and even twelve incisions. This, as I shall show, is no more a question of mere chance, as I believe is generally supposed, than it is for the high and low breeds respectively of any animal to produce offspring after its kind. The poor, relatively to the more copious drug-yielding poppies, are so from a less specialized or increased function, and this again is dependent on the enlarged development of the drug-secreting system. Thus, in my opinion it is as feasible for us to expect equal quantities of milk from a mixed dairy of high and low bred cows, as from that containing high bred animals only, or again, to expect an uniform offspring of high bred animals from a commixture of those with lower races. These relations have hitherto been singularly overlooked in the case of the poppy: no attempt whatever, so far as I can learn, has been made to separate the scanty from the copious drug-yielding plants. Thus, as might be expected, we have great fluctuations in produce, even as chance decrees, or rather in accordance with the physical conditions favorable to the peculiar wants of the less or more highly organized varieties. Reasoning from analogy, we can understand that the seeds of one or other may germinate in a shorter period and with greater vigour, and thus having the ascendency of the other in the thinnings out, they will naturally have the preference, and thus form the larger proportion of the crop, even should equal quantities of seed be sown. Again, in the above case, the first race might germinate while the weather was hot, dry, or otherwise unfavorable to the nascent plant, and thus receive a check from which they never fully recovered, while, on the other hand, the later race, springing up under more genial conditions, will outgrow their stunted congeners, and thus, favored by nature and the subsequent artificial thinnings, form ultimately the greater part of the crop. I would thus explain largely

the fluctuations in the outturn of opium from season to season, and also those still more striking fluctuations in the produce of adjoining, and in all respects similarly treated fields in any particular season. I am now firmly convinced that it is not now as I had hitherto regarded it, a question of manure, but one which has relation chiefly to the selection of the crop. This we well know has hitherto been delegated to nature. The artificial thinnings are but a supplement in favoring only the fittest, *i.e.*, the most vigorous: we have never had in view a process of favoring the copious and eliminating the poor drug-producers. This, during the latter part of the past season, I have had strictly in view, and all the seed of my experimental gardens has been carefully selected and graded by the number of incisions which have yielded drug. From my best seed, I look forward with the greatest confidence to a crop which will yield from three to five times more opium than the mixed one from which I selected the seed in the past season. In advancing these views I have been told that if there had been anything in them, the native cultivators or others would not have so long overlooked them; in reply, I can but say, await the result of careful experiments. Others, while fully agreeing with me in the general principle, are of opinion that I am over-sanguine in assuming that by a single season's selection of seed, I shall have a three to five-fold increase of opium. This, however, as I have already remarked, is from a simple misapprehension of the real basis of my assumption. I look forward to and calculate from, no increased produce from the more copious producers of the past season; I but accept them at their existing grade of fertility, eliminate their poorly productive congeners, and thus from a crop of the most copious drug-producers only, I see no reason why we should not get from three to five times more opium. As to the actual conditions of the poppy crops now, *i.e.* with relation to the proportion of poor to the more copious drug-producing plants, I have simply to refer to the several tabular statements in which the returns are shown of the best varieties which could be supplied me from the several divisions of the Behar Agency; these I consider a very fair index, and one which is fully borne out by the annual outturn of opium. From this point of view, I do not think that I have at all over-estimated the results, and I take the liberty of saying that one of the officers of the Behar Agency, well qualified to take a practical and theoretical view of the question, wrote me on receiving a copy of my letter, (circulated by the Opium Agent of Behar) and, as to the result of the suggestion, in quite as sanguine terms as any that I have yet expressed. Fully confident though I am as to the increased returns of my next season's experiments, I was much gratified to find that they were so readily and favorably accepted by an experienced officer of the department.

2. I shall now briefly illustrate the morphology and structure of the capsule of the opium poppy. The seed-vessel of the cultivated opium poppy does not dehisce or open naturally by chinks or pores under the stigmas as in the case of its wild progenitor—(compare figures 1 to 5 of plate II with figure 6). This (the non-dehiscence) I may explain here, is simply a result of drug-extraction, which by increasing, directing, and prolonging the circulation in the pericarp, and thereby enlarging its vascular system, thus causes the placental or seed-bearing walls, and the pericarpal or enclosing walls to dry up simultaneously, and there is thus no shrinkage in the inter-placental parts to effect the normal dehiscence. It will also be observed by reference to plate V, figures 11 and 12 (which respectively represent what I may be allowed to call in plain language the woody skeleton of the poppy seed-vessel in the wild and cultivated forms) that in the latter while the woody tissue is extended to, and unites with that of the stigmatic rays, in the other figure it is discontinued below the stigmatic rays; and ~~thus~~ the early shrinkage of that part causes the dehiscence or formation of chinks under the stigma for the discharge of the seeds. In this, and in this character only, have we a morphological distinction between the improved opium-yielding poppy and its wild progenitors. On plate III, figures 6 and 7, we have transverse sections of poppy capsules, showing that the placentation is parietal, the infolded margins of the carpel not being united in the centre; the seeds as shown (*vide* 6*a*) cover the sides and face of the placental processes. Again, figure 8, plate V,

is an enlarged view of one of those partial dissepiments showing the internal network of vascular tissue given off by the *costa* for the support of the seed. A single capsule of the Oriental poppy (*P. orientale*,) is said to contain 32,000 seeds; neither the opium nor its wild congener however, contains anything like this number. The weight of 1,000 seeds of the opium poppy is on an average 5 grains, and as I have found that from 75 to 80 grains is about the extreme produce of a single capsule, the seeds being air-dried only, we would thus have from 15,000 to 16,000 seeds, or just about half the number produced by the Oriental poppy.

3. In figure 9, plate V, we have a diagrammatic section of a portion of a poppy capsule, showing the disposition of vessels in the pericarp, placenta, and stigma. The pericarp, or covering of the seed-vessel, consists of three distinct layers: the outer or epidermal, forming the skin (technically called the epicarp), *a*; the middle one, composed of several layers of hexagonal cellular tissue (technically forming the mesocarp) *b*; and lastly, the inner and, from our point of view, most important layer (technically the endocarp) *c*; composed of loose cellular tissue permeated by a fine network of drug-yielding vessels, *f*; and a loose and irregular network of reticulated and dotted vessels, *g*; forming probably organs of absorption. The section, it will be observed, passes down the placenta, exposing first the structure of what is simply the mid-rib of the carpellary leaf, and its ramification in the interior of the placenta. It is composed of cords of reticulated, spiral, and annular vessels, varying from 400th to the 800th and 1,000th of an inch in diameter; and passing along its outer face we find a large milk-tube, usually about the 400th of an inch in diameter. Again, on the interior face of the mid-rib we find extending a similar but finer milk-tube, from which innumerable ramifications, from the 800th to the 1,000th of an inch, permeate the placenta and form an irregular network of miniature chains: a disposition unfavorable to rapid circulation, but specially suited to the placental requirements. The stigmatic ray, it will be observed, is composed of four distinct layers: first we have a deep layer of loose cellular tissue, invaded by a network of spiral and reticulated vessels ~~and continuations~~ from the mid-rib. Superposed on this we have a single layer of arch-like milk tissue (*i*), on which rest a layer of cellular tissue (*j*), and finally the papillose surface of the stigma (*k*), on which rest numerous pollen-grains (*l*), protruding tubes (*m*), which pass downwards and fertilize the ovules (*n*). In figure 11 we have a much enlarged view of the pollen-grains. These are oval, oblong, and longitudinally sulcate. Again, in figure 11*a* these grains are shown as on the stigma, swollen up with its imbibed moisture and protruding tubes: two in one case proceeding from a single grain.

4. In the above diagrammatic section, I have exhibited the general disposition of the vascular system in the poppy capsule, we have now more particularly to consider ~~them in their~~ functional relations. First: figure 8, plate V, exhibits a longitudinal section of the pericarps or placental axis. The epicarp *a* is formed of a single layer of colorless thick-walled vessels, ultimately forming an almost horny membrane, and having numerous stomæ or breathing pores, which, communicating with the intercellular spaces, and at least facilitate the process of respiration. Figure 7, plate VI, shows a highly magnified portion of the epicarp with these stomæ; the latter consist of two parallel cells which open by curving outwards, as at *a*; others, it will be observed, are more or less closed, *b*. They are found also on the sepals, the underside of the leaves, and on the outside of the stem; on the capsules I have counted from 12 to 23 on the 180th of a square inch; sepals from 2 to 6; outside of the stem from 10 to 12, and on the underside of the leaves from 25 to 36 on the above space. The succeeding zone forming the middle or mesocarpal zone, is formed of from 8 to 10 layers, of which the outer is composed of a single row of regular roundish oblong cells. The cells of inner layers are of an irregular hexagonal shape: all contain anylaceous granules. The endocarp, or inner zone, consists of a loose network of hexagonal cells (containing green coloring matter, technically called chlorophyll,) the intercellular spaces of which are everywhere

invaded by the milk and absorbent vessels: first for the milk or drug-secreting vessels. In the more copious drug-producing capsules this system is very largely developed. Figure 8, plate VI, is a portion of this system from a longitudinal section of the pericarp; forming an irregular but compact network of vessels, of which the majority are from the 500th to the 800th of an inch in diameter, and thus afford (considering the depth and circumference of the zone through which they extend) a considerable drug-secreting capacity. This system is much less developed in the capsules of poor drug-producing plants, and, as a rule, the woody system (as shown in figure ~~13~~, plate V) is very much more fully developed. This will be observed by comparing figures ~~13~~ and ~~14~~, the latter showing the disposition of the woody tissue in a copious drug-yielding capsule, while the former exhibits it in a degenerate and poorly productive form. Again, with a comparative paucity of vessels in the latter form, they are of smaller diameter, rarely exceeding the 800th of an inch, thence passing to tiny tubes of 1,000th to the 1,500th of an inch. Thus, as I believe, it is owing to the poorly developed and much attenuated drug-yielding system that the large proportion of our poppy crops yield such a small quantity of drug. This, it must further be remembered, is a result of congenital structure, and that accordingly such individuals under the most favorable conditions will relatively prove poor drug-producers. I have frequently had what I now know to be plants with a poorly developed milk system pointed out to me by the natives with surprise, as still being fresh, green, and even producing flowers, ~~yet~~ every capsule had ceased to yield a drop of drug when incised. I was much struck when I first observed this, and I then began to make the anatomy of the poppy seed-vessel a special study. My other duties, however, have prevented my working it out so exhaustively as I could have wished, but this much I have certainly learned, that the poor relatively to the copious drug-producing plants, are so from well marked differences in the degree of development of the drug-secreting system. Until this fact is fully recognized and acted upon, by a careful selection of seeds from the more copious drug-producing plants only, or what is better, the best or most copious drug-producing capsules, it is simply ridiculous to expect any well-marked or permanent improvement in our poppy crops. Of this I am fully convinced, but arguing, as I do, from analogy, I may fail to carry conviction to others until we have actual demonstrations, and these I am confident will be afforded by my next season's experiments. Experience and analogy are anyhow alike in my favor, and I only wish for the good of the native cultivators (so assured am I of success) that the carrying out of the simple suggestions I have made had been somewhat enforced on them. I am glad, however, to say that ~~from~~ at least one district of the Behar Agency the system will be partially adopted, as the Sub-Deputy Opium Agent has written me that some of his best cultivators at once approved of, and adopted the plan of selecting seeds from the more copious drug-producing capsules. His regret was that my suggestion had not reached him earlier, as he was certain if it had, that it would have been more generally adopted in the division.

5. Associated with the milk-vessels in the endocarpal zone, we have yet another interesting system of vessels, ~~b~~, figure ~~10~~, plate VI: they consist of reticulate and dotted tubes only, and, as will be seen from my figures, assume remarkable forms. As a system, it will be observed, to be strictly confined to the endocarpal or inner zone, neither uniting, on the one hand, with the vascular system of the *placenta*, nor passing outwards into the middle zone of the pericarp: abutting against both, it then curves inwards or upwards and anastomoses in a curious and irregular manner. As shown in figure 1*a*, and ~~3~~, plate V (representing a section on the plane of the pericarp), the milk-vessels, *b*, are associated with the above system. The latter being quite distinct from the ordinary vascular system, I (following Herbert Spencer, who has figured very similar organs from the leaves and stems of various plants in his principles of biology) am disposed to regard them as absorbent organs, the peculiar function of which is to absorb matter from the surrounding tissue for transfer to the frequently drained system of milk

vessels with which they are associated. I shall have occasion to allude to them in a subsequent paragraph. In the meantime, I may explain that figure 1*a* and *b* exhibit them from sections on the plane of the capsule; figure 2*a* and *b* are from a transverse section, and figure 3*a* and *b* from a longitudinal section. As supporting the functional view I have taken of the above system, it is noteworthy that it is much less fully developed in poor than in copious drug-producing capsules. From this endocarpal zone we pass on to the sub-placental costa *e*, consisting of a series of milk tubes, and of which the placental system of these vessels are ramifications. Again, figure 9, plate VI, exhibits an enlarged longitudinal view of a portion of the placental costa; *a*, an annular tube; *b*, a series of spiral tubes, and *c*, a large milk tube, the ramifications of which form the chain-like system of milk-tubes in the placenta *ee*.

6. I shall now proceed to illustrate the modes of extracting the drug as usually practised in India, *vide* figures 2, 3, 4 and 5 on plate II. By far the most general mode appears to be that illustrated by figure 2, and in which it will be observed that the incisions (extending from the base to the stigma) have been made with a four-bladed *nushtur*. In some districts, and in the Benares more than the Behar Agency, three and two-bladed *nushturs* (figures 3 and 4) appear to be not unfrequently used. Where the plants are poor drug-yielders, and do not afford full incisions to the four-bladed *nushturs*, the latter may be used with advantage, and especially the two-bladed, as in cases where the drug may be more copious, the incision may be repeated; this has been done in three out of the four incisions shown on figure 4. The last mode which I will notice (figure 5) appears to me to be a very objectionable one, and it is difficult to understand how it has been introduced. It is known as the "*Tikúlea pās*" from the incisions having some fancied resemblance to the marks on the forehead of native women. The incisions are made with a three-bladed *nushtur*, generally twice or even thrice repeated, and as a rule confined to the upper half of the capsule. The result of this is, that the greater portion of the drug in the lower part of the capsule is lost, as I have repeatedly observed that after even a very severe incision of the upper half of the capsule, the drug still flowed freely to incisions on the lower part. This is not the case after a full longitudinal incision. When the drug is thus allowed to remain in the lower system of milk vessels, a part of it is quickly deposited over their whole inner surface, thus thickening the walls and obstructing the subsequent flow of fluid. Indeed, I find a great tendency to this in the larger sized, roundish or oblate capsules, and it is a great advantage to lance them (according to their size) on the first, second, and third occasions on opposite sides: it is thus only that a general depletion of the drug contained in the milk vessels of the capsule can be effected. In making an incision on one side of a large broadly-oblate capsule, the capilarity of the vessels retards the flow of fluid from the opposite branches of the system, and the supply to the drained portion is, as I believe, chiefly from below (the stem) upwards.

7. From the general distribution of the drug-secreting vessels in the inner pericarpal zone, it is evident that no better mode could be suggested for the extraction of the drug than that generally adopted. In the transverse sectional figure of a portion of the pericarp and three placenta, *vide* figure 10, plate VI, it will be observed that the incisions *aa* but penetrate and cut the outer series of the milk vessels, while the others, though well drained of their contents, are left intact for future work. The incisions indeed but break the continuity of the vessels, and these soon close up and resume their functions, as we find that though the blades of the *nushtur* are scarcely more than the 1-16th of an inch apart, nevertheless the intermediate tissue if lanced on the second or third day following will again yield drug; thus showing that it had sustained really no injury from the previous incision. I may here observe that the pericarpal layers of the local poppy are considerably thicker than those of the Malwa varieties as cultivated here, and the latter thus require to be lanced very carefully. This was so much the case that only a very few of those I had engaged could operate on the Malwa capsules, though expert enough on those of the local poppy; the tissue of the former being not only thinner but softer, they

were very apt to cut through the whole of the layers and expose the interior. Again, the milk-vessels of the Malwa, as compared with those of the local poppy, seem, as a rule, to be of somewhat smaller diameter, so that in making the incisions we frequently observe the drug oozing out at points from one-twelfth to one-sixteenth of an inch apart along the surface of the scarifications. I have thus counted along the incision of a single blade from 28 to 39 drops. Generally from two or more points the juice oozes copiously, and at once trickles down the cut if of low consistence.

8. As well showing how greatly deteriorated the poppy crops at present are by the predominance of poor drug-producing plants, I, on the 14th March, collected the drug from 50 capsules of poorly productive varieties, and from the same number of the more copious drug-producers. In each case the collection was made from the second incision on the capsule, and in the inferior drug-yielding plants from a single capsule only on each plant, whereas, in the other case, I took it from two to three capsules on one plant; by taking it from the best capsule only of each, the contrast which I will now show would have been considerably increased. The crude drug from 50 capsules of the poorly productive varieties weighed only 23 grains, whereas that from the same number of the superior class yielded 140 grains, that is, fully $6\frac{1}{2}$ times more drug. Now it is worth while referring to the tabular statements of the past season's crop to ascertain the average proportion of the poor and more copious drug-producing plants, and thus make a comparative estimate of the produce of an uniform crop of poppy (say of one beegha) in its present mixed state, and after selection and elimination of all poor drug-producing plants. I will allow 27,225 plants per beegha (*i.e.*, one square foot to each plant, though they should really not have more than six or nine inches) of which 4,537 only are fairly copious drug-producers, while the remaining portion, comprising 12,688, are of the inferior class. The results may be thus tabulated: *first* for the mixed crop as estimated from the above averages and the relative drug-produce of equal numbers (50 as above shown) of good and inferior capsules, thus:—

1.	Poor plants	12,688	Relative proportions of poor and copious drug-yielders in present crops.
2.	Superior plants	4,537	
3.	Produce of selected seeds (plants) ...	27,225	
4.	Crude drug-produce of 3 collections in lbs. ...	12·0	
5.	Crude drug-produce of 5 collections in lbs. ...	15:5	
6.	Crude drug-produce of 5 collections in lbs. ...	263·80	
7.	Prepared drug—produce of No. 1 ...	4·0	Total in lbs. troy, 9·16.
8.	Prepared drug—produce of No. 2 ...	5·16	
9.	Prepared drug in lbs.—produce of No. 3 ...	87·93	

9. In the case of the inferior plants, I have of course limited the collections of drug to three, which is a high average, whereas for the best plants I have calculated from the low average of five; a fairer average would have been seven, which would have afforded an increase of 36·16lbs. of prepared drug. I see no reason to doubt that at least the average of five collections or 87·93lbs. troy, per beegha of prepared drug will be realized from the more carefully selected crops. I need scarcely add that the basis of my belief is simply the possibility of eliminating (and at once, by the process of seed selection above suggested) the poor from the more copious drug-producing plants, and thus have an unmixed crop of the latter only. The selective improvement of these will of course, as in all analogous cases, be the slow work of years, but as I have elsewhere remarked, I have no doubt that thus the best of our drug-producing poppies now may be as inferior to those of the future as these are superior to their wild progenitors.

10. Chiefly with a view of ascertaining the relative size of capsules, and amount of water in lanced and unlanced capsules, I requested both agents to send me from each division of their agencies twelve of the largest and most copious drug-producing capsules. Such samples have been forwarded to me from all the divisions, and indeed most of the sub-divisions of the Benares Agency, and also from those of the Behar Agency with few exceptions, one of which, Chota-Nagpore, as the Sub-Deputy Opium Agent explains, was due to a

severe hailstorm which had destroyed the best of his crop, and he did not care to send me inferior samples.

11. I have tabulated the results, not in full, as in many cases several samples were sent me from one division. In each case I have only selected a few of the best samples. The points I had specially in view in making such observations, was whether or not there were any regular or marked differences between lanced or unlanced capsules; *e.g.*, in the actual weight of capsule, its capacity as measured by small shot, the quantity of good seed produced, and the relative loss in water of the latter when dried at a temperature of 212°, Fahrenheit. As will be seen from the tabulated results, the variations are most indefinite and can be reduced to no rule. This has surprised me much, as I had anticipated marked differences, that the unlanced capsules should not only be heavier but of larger capacity, contain more seed, and that this also relatively to the produce of lanced capsules would show a greater loss in water after exposure to a high temperature. This is far from the case, however, the variations being quite as great and irregular under each head (though the capsules have now been unlanced for two successive seasons) as are those of the regularly lanced capsules. In the case of the irrigated relatively to the unirrigated lands, we find the same irregular variations, though this may be largely a result of the comparisons being made with different varieties of seeds, and this much I have generally observed when I had an opportunity of comparing similar varieties from irrigated and unirrigated lands, that the former produced as a rule heavier capsules, of larger capacity, and an increased quantity of seeds as compared with those on the unirrigated lands. I have, however, failed to detect any regular differences in the amount of water they respectively contained. The first column, however, of the two tables is of some interest as enabling us to form a distinct estimate (from that furnished by my own experiments) of the drug-producing quality of the best plants in the several divisions of both Agencies. It will be observed that the best in some districts do not afford even five incisions, and from this we find them dropping off to four, three, two, and even one. With such as the best selected samples of the several divisions, we must needs form but a poor opinion of the average drug-producers. On the other hand, many fine samples were sent me, both of large and medium-sized capsules, which had afforded from seven to nine, and even eleven full incisions. The seeds of these, as well as the others, I need scarcely say are reserved by me for next season's experiments. They are valuable as comprising, I presume, all the best varieties now cultivated in the two Agencies.

TABLE A.

Samples of Poppy Capsules from the Deegah Experimental Garden.

Number.		Number of drug-producing incisions on the capsules.	Total weight 12 capsules in grains.	Capacity of 2 capsules measured by small shot, in grains.	Total weight of good seed, the produce of column 2.	Weight of 7 cubic centimetres of seed air-dried in grains.	Weight dried at a temperature of 212° Fahr, in grains.	Loss in water grains.
1	Degenerate poppy, with small green reddish streaked flowers (4 capsules)	2—3	304·50	1,113	160·05	56·75	53·02	3·73
2	Ditto ditto ditto ...	Unlanced	300	1,232	157	57·12	54·04	3·08
3	Patna poppy capsules, oblong, ovate, glaucous ...	Ditto	1,431	5,724	749	56·53	53·80	2·73
4	Ditto ditto, globose, ovate, glaucous ...	Ditto	1,272	3,578	706	55·02	51 65	3·37
5	Ditto ditto, ovate, oblong, glaucous ...	Ditto	1,113	4,134	560	55·57	51·48	4·09
6	Benares ditto, roundish, oblate, glaucous ...	Ditto	1,431	4,770	850	56·50	52·06	4·44
7	Gungajull ditto, oblong, ovate, glaucous ...	Ditto	1,213	5,724	756	56·04	53·50	2·54
8	Benares ditto, globose, ovate, glaucous ...	Ditto	1,630	6,480	850	56·12	53·10	3·02
9	Patna ditto, globose, ovate, glaucous ...	Ditto	1,650	5,410	895	55·03	51·33	3·70
10	Uggyria ditto, ovate, oblong, glaucous ...	Ditto	1,213	5,724	686	56·02	52·08	3·94
11	Ditto ditto, ovate, oblong, glaucous ...	Ditto	1,173	5,288	688	56·85	53·12	3·73
12	Benares ditto, roundish, oblate, glaucous ...	Ditto	1,510	6,928	802	56·50	53·08	3·42
13	Patna ditto, roundish, oblate, glaucous ...	Ditto	1,312	4,124	826	56·80	54·10	2·70
14	Ditto ditto, roundish, oblong ...	8—12	1,810	8,580	951	59·35	56·25	3·10
15	Benares ditto, oblong, ovate	8—10	1,685	7,724	875	58·70	55·65	3·05
16	Patna ditto, oblong, ovate, (Var. kolodantic)	6—8	1,260	2,340	576	57·25	54·50	2·75
17	Chota Nagpore capsule, oblate, glaucous, (one capsule)	16	138	4,897	20	.....	.....	.....

TABLE B.

Samples of Poppy Capsules from the Benares Agency.

Number.		Number of drug-producing incisions on the capsules.	Total weight of 12 capsules in grains.	Capacity of capsules measured by small shot, in grains.	Total weight of good seed, the produce of col. 2.	Weight of 7 cubic centimetres of seed air-dried in grains.	Weight dried at a temperature of 212° Fahr. grains.	Loss in water grains.
1	Ghazeepore capsules, globose, oblate, glaucous, (Var. Majhee)	6—8	1,908	8,228	835	57·75	53·25	4·50
2	Ditto ditto, roundish to oblong, ovate, (Var. Gilguloa)	2—7	1,590	8,626	636	58·15	55·35	2·80
3	Ditto ditto, ovate, oblong, (Var. kalodantie)	2—3	1,113	2,862	636	58·35	55·20	3·10
4	Ditto from the factory garden, capsules, roundish, oblong, and ovate	5—6	1,431	3,120	656	58·85	54·75	4·10
5	Azimgurh capsules, oblong, ovate, glaucous... ...	4—8	1,528	6,360	784	59·85	56·01	3·84
6	Goruckpore ditto, oblong, ovate of a dull green color	5—8	1,074	4,134	477	57·90	56·30	1·60
7	Bustee ditto, roundish, oblong, glaucous ...	6—10	1,669	5,367	825	58·25	56·15	2·10
8	Futtehgurh ditto, roundish, oblong, glaucous ...	7—9	1,470	4,889	586	59·85	56·10	3·75
9	Ditto ditto, roundish, oblate, glaucous ...	6—7	4,032	9,858	843	59·75	55·12	4·63
10	Ditto ditto, ovate, oblong, glaucous, (Var. kutylea)	4—9	1,188	3,100	700	58·60	55·25	3·35
11	Fyzabad ditto, ovate, oblong of a dull green color	3—7	1,392	5,406	675	58·15	55·35	2·80
12	Ditto ditto, oblong, ovate, glaucous	3—7	1,400	5,724	675	59·12	56·07	3·05
13	Lucknow ditto, roundish, ovate, and oblate ...	6—8	1,590	9,022	742	59·35	56·20	3·15
14	Futtehpore ditto, roundish, oblong, glaucous ...	7—9	1,749	10,494	457	57·75	55·35	2·40
15	Ditto ditto, oblate and oblong, glaucous ...	4—5	1,272	5,844	626	57·12	54·15	3·07
16	Ditto ditto, ovate, oblong, glaucous	5—6	1,054	4,124	466	58·20	55·06	3·14
17	Bareilly ditto, roundish, oblong, glaucous ...	7—9	1,660	9,470	636	59·15	56·30	2·85
18	Ditto ditto, oblong, ovate of a dull green color	5—9	1,908	6,878	936	58·60	56·25	2·35
19	Ditto ditto, roundish, oblong, glaucous ...	5—9	1,752	7,622	802	59·25	56·25	3·00

TABLE C.

Samples of Poppy Capsules from the Behar Agency.

Number.		Number of drug-producing incisions.	Total weight of 12 capsules in grains.	Capacity of 2 capsules measured by small shot, in grains.	Total weight of good seed, the produce of col. 2.	Weight of 7 cubic centimetres of seed air-dried, in grains.	Weight dried at a temperature of 212° Fahr. in grains.	Loss in water—grains.
1	Tirhoot (irrigated land) capsules, oblong, ovate, (Var. kalodantie)	6—10	954	2,784	530	59·12	55·08	4·04
2	Tirhoot (irrigated land) capsules, oblong, ovate, of a dull green color	6—10	1,272	4,204	656	60·08	57·02	3·06
3	Tirhoot (irrigated land) capsules, oblong, glaucous ...	1—6	834	2,622	366	59·75	56·60	3·15
4	Ditto (unirrigated land) capsules, oblong, ovate...	3—7	1,010	2,498	460	58·25	55·15	3·10
5	Ditto Ditto, capsules, oblong, ovate, of a dull green color	3—5	1,014	3,418	527	58·60	55·35	3·25
6	Tirhoot Ditto, capsules, oblong, glaucous	2—6	1,112	4,040	660	59·15	55·12	3·03
7	Hajeepore (irrigated land) capsules, roundish, oblate, glaucous	6—11	1,780	7,712	905	59·35	56·50	2·85
8	Hajeepore (irrigated land) capsules, roundish, ovate, glaucous	6—8	1,233	4,770	546	60·25	57·85	2·40
9	Hajeepore (unirrigated land) capsules, ovate, oblong, of a dull green color	5—7	1,272	4,770	702	58·50	55·06	3·44
10	Hajeepore (unirrigated land) capsules, oblong, ovate, glaucous	4—10	1,233	5,088	666	59·40	54·85	4·55
11	Hajeepore (unirrigated land) capsules, ovate, oblong, of a dull green color	3—8	1,014	2,300	546	58·95	55·65	3·30
12	Chupra capsules, roundish, oblate to oblong	7—11	1,232	4,531	636	59·30	55·75	3·55
13	Ditto, oblong, glaucous	6—9	1,629	6,200	715	58·25	56·12	2·13
14	Alleegunge (unirrigated land) capsules, ovate, oblong	3—8	1,074	5,924	624	59·75	55·85	3·90
15	Alleegunge (irrigated land) capsules, roundish, oblong	4—7	1,500	5,824	708	58·25	56·10	2·15
16	Motiharee (unirrigated land) capsules, ovate, oblong, glaucous	4—6	1,193	3,816	670	58·75	55·24	3·51
17	Motiharee (irrigated land) capsules, oblong, ovate, glaucous	4—7	1,352	5,088	664	59·20	56·35	2·85
18	Bettiah (unirrigated land) capsules, ovate, oblong, glaucous	6—8	1,113	5,088	408	59·85	55·90	3·95
19	Bettiah (irrigated land) capsules, ovate, oblong, glaucous	5—8	1,392	5,770	784	59·50	55·05	4·45
20	Gya capsules, oblong and roundish, oblate, glaucous	5—9	1,670	7,950	795	58·50	54·75	3·70
21	Tehtah capsules, oblong, ovate, glaucous, and of a dull green color	6—8	1,331	4,810	730	56·84	53·95	2·89
22	Patna capsules, roundish, ovate, glaucous, (Var. Doodhea)	6—11	1,590	7,155	775	57·15	54·25	2·90
23	Patna capsules, roundish, oblong, glaucous, (Var. Goonjua)	7—11	1,152	4,452	630	58·35	55·20	3·15
24	Patna capsules, oblong, of these texture, (Var. Gouria)	6—9	1,272	5,724	545	58·75	55·50	3·25
25	Patna capsules, oblong, ovate, glaucous, (Var. Bhagantea)	6—9	1,192	4,670	636	58·70	55·65	3·05
26	Patna capsules, oblong, ovate, (Var. Monneria) ...	5—9	1,152	4,442	632	59·10	56·30	2·80
27	Ditto, oblong, ovate, glaucous, (Var. kutylea)	5—8	1,232	4,093	636	58·15	56·10	2·05
28	Monghyr capsules, glaucous, roundish, oblong ...	7—11	1,550	6,519	706	58·25	55·50	2·75
29	Ditto, of a dull green color, oblong, ovate	7—9	1,192	7,833	595	59·08	56·45	2·53

12. This seems as fit a place as any for illustrating the relative value of the seeds of lanced and unlanced capsules as oil-yielders. In the following tabular statements I have given the results, in which the first column gives the quantity of seed, the second the quantity of oil extracted, the third (to facilitate comparison) gives the calculated produce, and the fourth and fifth columns, the actual and calculated produce of oil-cake :—

A.—Lanced Capsules.

	Seed.		Oil.				Oil-cake.			
	Srs.	Ch.	Srs.	Ch.	Srs.	Srs.	Srs.	Srs.	~~Srs.~~	Srs.
Benares poppy, large capsules ...	3	8	0	15	100	— 26·79	2	9	100	— 73·21
Patna „ small „ ...	2	9	0	13	...	— 31·70	1	12	...	— 68·29
„ „ large „ ...	29	3	11	4	...	— 38·54	17	15	...	— 61·24
Average produce ...	11	12	4	3	...	— 32·34	7	6	...	— 67·58

B.—Unlanced Capsules.

	Seed.		Oil.				Oil-cake.			
	Srs.	Ch.	Srs.	Ch.	Srs.	Srs.	Srs.	~~Srs.~~	Srs.	Srs.
Benares poppy, small capsules ...	7	4	2	3	100	— 30·17	5	1	100	— 69·82
„ large „ ...	31	0	11	7	...	— 36·89	19	9	...	— 63·10
Patna poppy, small „ ...	44	13	16	5	...	— 36·40	28	8	...	— 63·50
„ large „ ...	3	10	1	4	...	— 34·48	2	6	...	— 65·51
Average produce ...	21	10	7	12	...	34·48	13	14	...	— 65·50

C.—Unlanced Malwa Capsules.

	Seed.		Oil.				Oil-cake.			
	Srs.	Ch.	Srs.	Ch.	Srs.	Srs.	Srs.	Ch.	Srs.	Srs.
Lukria *var.*	40	4	14	7	100	— 35·87	25	13	100	— 64·13
Uggarya „	2	5	0	11	...	— 29·72	1	10	...	— 70·27
Average produce ...	21	0	7	9	...	32·79	13	11	...	— 67·20

D.—Lanced Capsules—Fresh Seeds.

	Seed.		Oil.				Oil-cake.			
	Srs.	Ch.	Srs.	Ch.	Srs.	Srs.	Srs.	Ch.	Srs.	Srs.
Patna poppy	36	0	13	1	100	— 34·72	22	15	100	— 63·71

13. In undertaking the above experiments I naturally anticipated a considerable increase of fatty matter in the seeds from the unlanced capsules. Indeed the results of the oil extraction from the local varieties of poppy do show an increase of about 2 per cent. in favor of the unlanced capsules, but I am inclined to attribute this to the seeds not having been sufficiently pressed in one of the samples from the lanced capsules. This was in the case of the large capsuled Benares seed, (*vide* table *a*), which yielded less than 27 per cent. of oil, with a proportionate increase of cake. The latter was unfortunately mixed with that of the other samples before I had made any comparison of the results, and I thus could not ascertain separately the quantity of fatty matter left in the cake. This was also too small in quantity to materially affect the total results. In repeating the experiment with seeds from lanced capsules from the past season's crop, (the previous experiments being with the seed produce of 1873), my suspicions were confirmed. I have given the results in the tabular statement *d*, a comparison of which with those of *b*, shows a slight increase on the relative percentage in favor of the former. The comparative decrease in cake is due to loss in water, of which the new seeds contained more than the old seeds.

14. I thought it worth while also to ascertain the relative amount of water and oil in each of the cake samples. The results are shown in the following tabular statement. I may explain that in ascertaining the amount of water, I thoroughly dried the specimen in a sand bath at a temperature of 212° Fahr., and for the oil I treated the cake, (previously reduced to a fine

powder, with ether; poured off the latter with its fatty extract into an open glass vessel, where the ether evaporating left the oil behind.

	Cake.	Water.	Oil.
A.—From lanced capsules	100	7·86	8·75
B.—From unlanced capsules	0	8·78	9·25
C.— Ditto ditto	0	8·65	8·95
D.—From lanced capsules	0	9·26	9·50

15. The results are thus quite in unison with all the preceding experiments under this head: all proving that the extraction of opium from the poppy capsule, neither reduces the weight nor capacity of the latter, nor does it affect the seed in actual size or even in the amount of water and fatty constituents. Variations we have indeed found, but these differ neither in degree nor kind from those of the lanced capsules.

SECTION VI.

FERTILIZATION IN ITS RELATION TO THE SECRETION OF DRUG.

1. My attention was first drawn to this point by the following remarks of Dr. Hooker in a letter to the Under-Secretary of State for India, dated 11th December 1871, and treating on the so-called blight which had so seriously affected the previous crop of poppy:—"On certain points" remarks Dr. Hooker, referring to the pamphlet sent him on the above subject of very great importance, "I find no satisfactory observations, especially on the condition and duration of the expanded petals and of the stamens of the diseased plants. The amount and quantity of opium secreted in the capsule depends on the full evolution and persistence or fall of the petals, and the fall of the petals is not a mere accident of growth, but largely depends on the reproductive functions of the plant. For if the ovary is impregnated properly, the petals may be expected to fall early and simultaneously, and the secretion of opium to follow rapidly and healthily; but if the ovary is not impregnated properly, the petals may be expected to hang longer, using up the nutritive juices of the plant and proportionately hindering the secretion of opium. These are not theoretical matters, but practical. It may well be that a failure of fecundation was one predisposing cause of the small yield of opium, and that the intermixture in the field of a few poppy plants of an inferior character as opium producing, but of a superior character as to fecundating potency, might by fecundating the crop have increased the yield." With a view to elucidate these and other points suggested by Dr. Hooker, I made many experiments during the past season, a few of which I will here record, beginning with the germination of the seed. The period required for this entirely depends on the humidity of the soil and the atmosphere. Under favorable condition the seeds will germinate in from five to seven days; very generally we find them taking from 10 to 14 days, and during the past season I have observed several cases of their germination after being a whole month in the soil. In these instances the seeds had been sown on an insufficiently moist soil, a few days after sowing it was re-watered, and under the heat of the sun soon became quite a dry cake, wholly preventing the tiny poppy to burst through, so that after a second watering had failed I had given up all hopes of their germinating. It was too late in the season, however, to think of re-sowing, and the plots were thus given up. On the 12th of January, however, we had a heavy shower of rain, and this (though the seeds had been more than a month in the soil) at once induced germination, and the whole soil was studded with the young plant's tiny leaflets. It was of course too late in the season for their coming to much, and indeed few of them made any further progress, nevertheless the above results show us how sensitive the seeds of the poppy are to the conditions of the soil. I should further explain, that after careful comparative observations of young crops which have germinated in from five to seven days, with those which have taken from 10 to 14 and even 20 days, I have been unable to detect any difference in the subsequent vigour of the crops. The

period intervening between germination and the appearance of the first flower varies much, and depends largely on the state of vigour of plant. The earliest of my last season's crop, sown on the 15th of October, germinating from the 23rd to the 28th, began to flower on the 6th of January, and the first collection of opium was made on the 22nd of that month, *i.e.*, 99 days from the time of sowing; other later sown crops began to produce drug in from 60 to 70 days. I have particularly attended to the duration of the petals, and find as a rule that the central or terminal secondary and even tertiary flowers fall on the morning or by noon of the third day after expansion, while the later flowers very generally fall on the second day, while late in the season small flowers on slender shoots rarely last more than one day. I fertilized numerous flowers with own pollen, cross-fertilized others, and compared them with those untreated, but found no difference in the duration of the petals. Indeed the stigmatic rays of the first and largest flowers are not in full condition to receive the pollen until the second or even third day of expansion, though they are generally more or less dusted with it on the first day from their own over-topping anthers. The fact, however, that the stigmatic papillæ are only fully developed on the third day shows, I think, that fertilization has not been previously affected, and I think the following out of many similar experiments go to prove that fertilization neither accelerates nor retards the fall of the petals, nor does it appear to have any effect on the drug-secreting qualities of the capsule.

A. Opened six flowers on the day prior to natural expansion and carefully cut off the stigmatic rays; flowers in each case expanded for three successive days; capsules attained a medium-size, and indeed were only distinguishable from the generality of those around them by the absence of the stigmatic rays. From the fall of the flower until the first collection of drug eight days intervened, and the capsules yielded a fairly copious supply of drug to from six to ten incisions. On collecting the capsules they did not contain one good seed; all were mere abortions.

B. Six other flowers were opened, and all the stigmatic rays carefully cut off; with one exception, the flowers fell off in the normal time and the capsules yielded a fairly copious supply of drug. I should also have explained that I fertilized the single stigmatic ray; each capsule produced a few grains only of good seed, and this, somewhat to my surprise, was not confined to a single placenta but occurred on them all from about the middle upwards.

C. I made similar experiments, leaving two and three stigmatic rays only at regular distances, and always artificially fertilizing these. The only difference in these cases was an increased quantity of good seed in the capsules; the fall of the petals and the secretion of drug was in no way affected.

D. Again, on the morning as several flowers were naturally expanding, I applied in some cases glycerine, in others poppy-oil to the stigma: thus carefully coating its whole surface. The result was that the majority of the capsules wer all but quite abortive, and those that did increase in size did so only towards the base; the portion immediately under the stigma being quite arrested. In no case were any seeds produced, though the partially developed basal portions yielded a little drug.

2. I was not at all prepared for such results, and I repeated the experiments many times, especially those in which all the stigmatic rays were cut off; the result was the same in every case. I found, however, that almost invariably in cutting off the stigmas on the second or even a few hours after the expansion of the flower on the first day, ~~that~~ a partial fertilization ~~had~~ was been effected, and a few good seeds were almost invariably produced. This is not the case when the mutilation is effected prior to the natural expansion of the flower, as in all my experiments this caused the utter abortion of the seeds, though the walls of the capsules were nevertheless very fully and regularly developed.

3. In a few cases, after cutting off the whole of the stigmatic rays, I made a small opening in the capsule and dusted the young ovules with pollen, but this had no effect; the seeds were all abortive, though the capsules increased in size and yielded drug.

SECTION VII.

THE SECRETION OF DRUG.

I will now introduce the results of a single experiment which I made in collecting the drug from the capsules on the day of their incision. The lancing was performed from 12-30 to 1-30 P.M., and the drug was wholly collected by 5-30 P.M., so that none of the drug had been exposed for more than five hours. Afterwards I had the sample prepared in the usual way. I showed it to the Principal Assistant of the Behar Agency, and both he and his Head Assistant told me that they had never seen a finer sample of opium, *i.e.*, judging from its physical characteristics, as color, aroma, and texture, which above all others enhance the value of commercial opium. How it may have affected the development of the alkaloids, subsequent analysis will show. It is important to observe that the drug collected as above contained no *pussewah*, and soon assumed a pale dullish-brown color, acquired quite a fruity odour, breaking with a ragged fracture and presenting an uniform and fine grain. In any books treating on opium which I have had an opportunity of seeing, I invariably find it stated that the exudation of drugs takes place mainly during the night. I had previously satisfied myself that this was a mistaken notion, and that the bulk of the exudations take place within from two to three hours after the lancing of the capsules, and even then chiefly from the larger sized milk-vessel, the smaller being closed. I however examined the capsules next morning, and finding that there were drops of drug sparingly scattered over the incisions (such, for example, as we generally find on the capsules shortly after collection in very moist or windy mornings) I had all gone over and collected. In place of the pale brownish colored drug, however, which I had got on the preceding day, I got a small quantity of a black *pussewah-like* drug. Under the microscope it presented a faintly brownish tinged base of serum, with numerous crystals varying much in size and shape, and of which none appear to be soluble in ether. I readily identified the morphine crystals, and this in considerable numbers; narcotine I failed to detect; there were, however, many other minute acicular and prismatic crystals which I could make nothing of under the microscope I was using. None of these crystals, however, were soluble in ether. The opium collected on the previous day, from the plants of which the above was the dregs, presents a very different appearance under the microscope; *serum* pale, almost colorless, containing numerous crystals; some unmistakably morphine, others minute, in rather irregular obliquely truncate prisms, with a few more or less distinctly acicular. I had no sufficiently powerful microscope to make anything definite out of these, and I had thus reluctantly to give up the examination. From the appearance of the two specimens, however, under the microscope, I feel certain that a careful chemical analysis will show marked differences in the two samples, of which the second or drug collection must, I think, differ but very slightly (chemically) from the *pussewah* which I have also sent for analysis. As regards crystalline matter, they do not greatly differ under the microscope; the main difference being in the serum, of which that of the *pussewah* has considerably more color.—*Pussewah* is very generally regarded as the more soluble principles of opium dissolved in dew; this is certainly a mistake, especially as regards the morphine matter; I find this but slightly and slowly soluble in cold water. Periera also remarks that "notwithstanding that it is insoluble or nearly so, in cold water, it gives to it a distinctly bitter taste. Boiling water dissolves a little more than 100th part of morphia." There is thus little grounds then for the belief that *pussewah* is merely the dew washings of opium. It is clearly an independent secretion, and, I am strongly inclined to believe that it is largely, if not wholly, the night oozings of drug from the vessels during gusty winds favored by moist weather. As far as my observations go, I have always observed a larger percentage of *pussewah* in the opium when gusty west winds prevailed during the night, than in still nights when the dew was heavy, or even light rain. We have then, indeed, the drug mixed up with a much larger amount of water, but when this is evaporated

we do not find any marked increase in *pussewah*. This, however, leads us to the general question of the influence of the weather in the produce of drug. "Most atmospheric causes" remarks Dr. Eatwell "influence the amount of produce, and cause alterations in the physical appearance of the drug are facts well known to every cultivator. Thus the effect of dews is to facilitate the flow of the juice from the wounded capsule, rendering it abundant in quantity, but causing it at the same time to be dark and liquid. An easterly wind (which in this part of the country is always concomitant with a damp state of atmosphere) retards the flow of the juice, and renders it dark and liquid. A moderate westerly wind, with dew at night, form the atmospheric conditions most favorable for collections, both as regards the quantity and the quality of the exudation. If, however, the westerly wind (which is an extremely dry wind) blows violently, the exudation from the capsules is sparing." Now while agreeing generally with Dr. Eatwell, I differ from him in some very essential points: first, as to "the effect of dews facilitating the flow of juice," I do not think that there are any very good grounds for this opinion; certainly in dewy nights we get a larger amount of crude drug, but absolutely no more opium than we would in a similarly still and dewless night. I, on the other hand, have observed that in a still, dewless, or, what is synonymous, cloudy night, I have on the following morning collected a larger quantity of fine opium-yielding-drug than in clear dewy nights; these really give but an increased bulk in water. Again, in the sentence following that on which I have made the above remarks, Dr. Eatwell, as it would appear, somewhat conflictingly continues "an easterly wind (here always concomitant with a damp atmosphere) retards the flow of the juice." Now there is much truth in this, but as it appears to me, it alike requires qualifications and explanations. A strong easterly wind, or I should rather say, a merely brisk wind of ten miles an hour and upwards, really does reduce the morning's drug-collections in a very marked manner. I have particularly observed this when the easterly wind prevailed during the night; having remarked that the exudations during the afternoon were plump and firm, nevertheless a brisk easterly wind through the night left but a mere film of drug for the morning's collections. More, really, than the watery contents had been abstracted, and I cannot help thinking (it may be, indeed is, unscientifically) that there has been a partial re-absorption of drug by the pericarpal vessels. There is in fact a loss to be accounted for of more than mere water. Now the easterly winds, though moist as compared with that from the west (in our districts), is nevertheless, relatively to the poppy crops (as being of lower temperature), a dry wind. Thus, though losing by evaporation, they are still unable to contract any dew, as in the case of the dry westerly winds, which always ere morning sufficiently lowers the temperature of the soil and the plant to enable the latter to contract a less or more copious sprinkling of dew, and thus fully recoups all the previous loss. In referring above to the effects of the easterly wind, I have suggested that concomitant with the evaporation of the watery drug-constituents there may also be a re-absorption of other matters to explain the real loss in drug. This, I assume, as having frequently observed, as previously remarked, in the evening plump and firm exudations reduced to mere films during the night under a brisk easterly wind. Now, reflecting on the extensively developed system of reticulated and dotted vessels (*vide* figures 8 and 9, plate V) in the closest association with the milk-vessels in the capsules, it occurs to me that the functions of those must really be of an absorbent nature. I am the more disposed to take this view of their function, first because I find a much diluted and almost watery fluid in the placental milk-system (I of course refer to that curiously disposed chain-like system of vessels as shown in figure 9, plate VI), whereas in that of the stem, the leaves and the inner layer of the pericarp it is quite of a milky color and altogether denser. As it appears to me the milk-like drug is not, as generally supposed, elaborated by the leaves peculiarly (or in other words a product of vegetable digestion) but largely, if not wholly, a secretion of the milk-vessels which are distributed over all parts of the plant. As a mere leaf secretion we should have found the denser fluid flowing from above

downwards, whereas on cutting the stem we find a thin, faintly colored, watery fluid exuding from the lower surface, while from the upper oozes the elaborated milky colored drug; so it is also in the earlier stages of the plant's development. Thus, having regard to the composition of the seed, the relative weight and quantity produced in lanced and unlanced capsules, and the difference on the density of the fluids in the milk-systems of the pericarp and the placenta, I am inclined to believe that the latter system of vessels really contributes little to the nourishment of the seed. On the other hand, I am disposed to regard the extensively developed system of netted and dotted vessels in the pericarp as absorbents whose peculiar function is to transfer certain matters to the associated milk-system of the pericarp. This is supported by the fact of this system being more extensively developed in copious than in poor drug-producing capsules.

2. To return, however, to the influence of the wind on the secretion of drug, or rather as affecting its exudation, for it must be confessed that while the quality of the secretions is unquestionably affected by atmospheric conditions, those physico-chemical processes which really affect the secretion are as yet beyond the ken of the physiologist. I will now but illustrate the points under consideration by a few extracts from my diary. February 9th: morning hazy, wind *E. S. E.*; from 6 P.M. of the 8th to 6 A.M., the distance traversed (as indicated by Robinson's anemometer) was 31 miles only. Minimum temperature of night 44°6. Difference between dry and wet bulbs at 6 A.M., 0·5; temperature, 47°; crops dripping with dew; drug copious, but dark colored, and of low consistence from absorbed moisture. Remarked that the drug collections with an *E. S. E.* wind as above, are not only of lower consistence but of a darker color than with an *E. N. E.* wind; this as far as my observations go, holds even with the hygrometer indicating saturation, and it occurred to me that the darker color of the drug with an east by south wind might be due to the latter being more largely charged with ammonia. Opium by the absorption of this gas assumes a darker color.

3. February 10th: morning hazy, wind *E.*; from 6 P.M. of the 9th to 6 A.M., the distance traversed was 43 miles. Minimum temperature 53°. Difference between dry and wet bulbs 9°7: temperature 55°5. Drug fairly copious, rather dry but remarkably clear of pussewah.

4. February 13th: morning hazy, wind *W. S. W.*; from 6 P.M. to 6 A.M. had traversed 21 miles only; hourly average increased (during collection and previous) to 6 miles; minimum temperature 54°. Difference between dry and wet bulbs 2°0; temperature 54°. Drug on capsules plump and firm, of a lightish color, and with little pussewah; the plants covered with a hoary moisture (but no distinct dew drops), as if coated with their own condensed respirations.

5. February 15th: morning light clouds, wind *W. S. W.*, gusty, distance traversed from 6 P.M. to 6 A.M. 168 miles; minimum temperature 37°6′. Difference between dry and wet bulbs 2°5; temperature at time of reading 41°5. During the collection of the drug and for some hours previous, wind very gusty and traversing about 18 miles per hour. Drug thin, darkish colored, pussewah rather copious, as the drug was collected, fresh oozings of a thin palish colored juice were everywhere observable on the incisions; the irregular jirkings of the capsule under a gusty and brisk wind having kept open the wounds of the larger vessels, and thus probably caused an increase of pussewah. While convinced that strong gusty winds tend to increase the quantity of pussewah, I am fully aware that there are other conditions equally favorable to its development; the physical properties of the soil for example, as well as its chemical composition would appear to have a marked effect; and I do not doubt that irrespective of all physical relations, careful observations will show that different varieties of poppy produce different proportions of pussewah. If I mistake not, relatively to the damdetta produce of the two Agencies, the proportion of pussewah is much larger in the Benares than the Behar Agency. Indeed districts have quite a pussewah-producing stigma in the former agency, as for example the Bustee

division ; the opium-produce of which (*vide* annual report for 1870-71 of the Principal Assistant) is termed *Bustee Soup* from its low consistence and inferior quality.

6. There is but one or two other points under the present head which I cannot pass unnoticed: this is the influence that variety, atmospheric conditions, soil, and manure may have in determining the quality and relative proportions of the chemical constituents of the drug. I have intentionally placed variety first, as probably the most potent. Under the most varied conditions of soil and climate, we find for example that the *P. somniferum var nigrum* produces a much larger proportion of morphine than the *var album*. This holds throughout the races of the two varieties, under the same conditions ; for example, it has been shown that while *nigrum* will produce a drug with 20 per cent. of morphia, and only 6·25 of narcotine, the produce of the *var album* yields only 6·85 of morphia with the proportionately large increase of 33 per cent. in narcotine. Now in the two Agencies, Behar and Benares, the varieties of *album* are alone cultivated, and it is invariably found that they produce an opium with the less valuable alkaloid narcotine in excess of the morphine. As I have already remarked, this is no deterioration to the drug in the China market. It gives it, however, a decreased value in Europe, where it is chiefly wanted for the extraction of its alkaloids, and of which of course morphia is the most valued. Considering then the quantity annually required by the medical department of the Indian Government, I would strongly recommend the introduction of some of the varieties of *nigrum* for the special produce of the medical opium, or at least that portion of it which is required for the supply of the alkaloids. It does not appear, however, that variations in the relative proportions of the alkaloids materially affect the narcotic or other properties of the drug, so that it might serve both purposes.

7. The influence of atmospherical conditions has been generally noticed, and I would here only draw attention to one point not previously alluded to, viz., the effect of light and temperature on drug secretion. It is a well-known fact that under the shade of trees, the poppy produces little or no opium. But this is an extreme case, and under favorable exposure where the opium poppy is enabled to develope itself fully, we find variations in the degrees of light and temperature really affect the secretion of this drug less than almost any other I know of. We find similar varieties, under the most dissimilar conditions, producing much the same drug ; and this not only in quantity, but also in physical and chemical qualities. With all this similarity, however, in the local produce of narcotics, the opium poppy in all its varieties is greatly affected by any sudden change in the conditions of growth. Thus the Malwa poppy thrives but indifferently, and is for years a poor drug-producer in Behar or Benares, and so with the local varieties of these provinces in Malwa. So it has been found difficult even to get seeds of the Turkish and Egyptian poppies to germinate in the fields of the above provinces, and of those which did germinate, the subsequent vegetation was poor and weak; giving rise indeed to less or more mal-formed flowers, but no perfect seed. It is worthy of remark, however, that while these varieties failed all over the provinces of Behar and Benares, I have nevertheless grown them with fair success in the Botanic Gardens at Calcutta. I made indeed no attempt to extract drug from them ; but the plants were fairly vigorous, flowered, and produced good seed. "Most of our odoriferous herbs," remarks the author of the article "Botany" in the Library of Useful Knowledge, "are found in greatest perfection in places or countries in which the sunlight is strongest, as sweet herbs in Barbary and Palestine, tobacco in Persia, and hemp in the bright plains of extra-tropical Asia." We do not find this the case with the opium poppy, which when fairly acclimatized, produces under the most varied conditions of light and temperature, a very similar drug.

8. As regards the influence of the soil or manures on the development of opium, we really as yet know little or nothing. Up-land soils, as also newly broken in lands, it has been observed, produce generally a lighter colored drug than do low lands, or those that have been long under poppy, but it has

not, as far as I know, been as yet shown that they differ materially in their alkaloid composition. During the past season, and as previously recorded, I made many experiments with a variety of manures, but from the unusual drought and limited supply of water from artificial irrigation, really none of them got a fair trial. As the same variety of seed was used in all these experiments, the analysis of the opium will, however, show whether or not the proportionate development of the alkaloids has been in any way affected.

SECTION VIII.

DISEASES AND INJURIES TO WHICH THE POPPY IS SUBJECT.

The only other subjects which I purpose treating in the present report are the more prevalent and serious forms of disease and injury to which the poppy crops are subject.

1. *Gangrene.*—During cold and damp weather, patches of plant are not unfrequently destroyed by this disease, though at all seasons, and especially in the more advanced stages of the crop, individual plants more or less affected with it are not at all uncommon, and are readily recognized by their curved, depressed, and less or more rigid shoots, drooping leaves with their sides folded backwards or even somewhat revolute. The flowers also expand imperfectly, the stamens always more or less persistent and drooping, with dry and shriveled anthers; the development of the ovary is early arrested, and no good seeds are produced if the affection is general, as in the case of the plant figured, *vide* plate X. These are the more marked external symptoms, and of which the drooping palish colored foliage is the first to present itself. It appears suddenly and generally affects the largest and apparently most vigorous plants. On cutting the plant over towards the base the pith will be found in a less or more advanced stage of decay. A longitudinal section, from the neck of the plant upwards, generally showing it dry and shriveled below, adhering, in threads, to the surrounding woody zone, while upwards we find it passing from a pulpy putrid mass to less and less advanced stages of decay, until we reach the point where the affection is invading and reducing the healthy pith. Figures 1 and 2, plate X show: first, the root and portion of the stem; the oblique cut at the neck of the plant exposes an empty cavity, the woody zones and bark being also much discolored, and the softer intermediate tissues quite rotten: 3. shows the disease in a less advanced stage, with the decaying pith still filling the inner zone but gradually drying up from below, as indicated by the protruding woody cords. The affection generally originates about the neck of the plant and has only an upward extension. It is worthy of note that, in innoculating healthy plants (which is readily done by inserting a small portion of the affected pith into that which is the subject of experiment) the disease makes scarcely any downward extension, which would seem to indicate that there is only an upward flow of sap in the pith. For the above disease in poppy there is really no remedy, all the softer inner parts of the plant being in an advanced stage of decay before any external symptoms present themselves. In softer tissued plants, where the inner and outer parts are almost simultaneously affected, its progress may be arrested by carefully cutting out the diseased portion and dusting the fresh cut with sulphur. From the nature of the disease, it will be readily understood, when young poppy of soft and vigorous growth become affected with gangrene, its extension and the ultimate destruction of the plant will be much more rapid than in the less vigorous or more fully developed and harder structured plants. The former would appear to have been the case with the plants affected in the Botanic Gardens, Calcutta, and thus referred to by Dr. King in a letter to the Assistant Secretary to the Government of Bengal: "the bed consists, or rather consisted,—for but few plants now remain—of well-nourished sturdy plants, standing at a considerable distance from each other, and in fairly well manured soil. The first signs of disease appeared on the lower leaves, which became black and shriveled; this was followed by a similar affection of the stem just where it emerges

from the ground. The disease progressed very rapidly in the stem, and soon the lower part of the latter was reduced to a mass of blackened fœtid pulp. In this condition it is unable to give support to the plant, which accordingly topples over, its upper leaves being still apparently unaffected." In this case, the damper conditions of the soil and moisture had much intensified the disease as compared with what we find it in the poppy field of Behar and Benares. Dr. King was kind enough to send me specimens of the affected plants to compare with those I had here, they differed only in degree, the Botanic Garden plants were also of a dwarf garden variety of poppy, and had much softer and thicker stems than any I had here. In one of the least seriously affected plants I had a sketch made of a transverse section of the stem at the base, *vide* figure 3, plate X. The pith was very largely developed, and in an advanced stage of decay, while the woody system was very poorly developed, forming a broken zone of wedge-shaped fasicles, as shown in the figure. Again, the cortical layers were largely developed, forming at parts about $\frac{1}{8}$th of the diameter.

2. A copy of Dr. King's letter, with other correspondence on the above diseased condition of the poppy in the Botanic Gardens, and those of the Agri-Horticultural Society, was subsequently sent to me by the Opium Agent of Behar. From this correspondence, I learn that His Honor the late Lieutenant-Governor had been apparently somewhat alarmed with the symptoms of the disease in the above gardens. In a letter, No. 800, dated the 4th April 1874, from the Assistant Secretary to the Government of Bengal, to the Secretary to the Agri-Horticultural Society of India, it is said to be "now clear by visible facts that the French poppy allied to the opium poppy is attacked by the same disease both on the Calcutta side of the Hooghly and the other, and the disease may well be connected with the blight in the poppy countries. But the fact may have two solutions: either (1) the disease may be an active and aggressive disease, and may spread, or (2) it may be a disease which attacks the plant when the conditions of soil and climate are unsuitable to its growth; *e.g.*, in Calcutta, or a place unsuitable to the growth of this kind of poppy." Low temperature with excess of moisture tend, as I have remarked, to induce this disease, and there is also in plants, as in animals, an individual predisposition, rendering some more susceptible to it than others, under the same conditions. I am thus not at all surprised to find the newly introduced French poppy suffering from *gangrene* under high culture in the Calcutta gardens. I do not think it would have suffered so severely in the drier climate of the poppy districts.

3. *Sclerenchymous* or *Scleriatic.*—Either of the preceding terms may be applied to the form of disease ~~which~~ we have now to treat; (*vide* figure 1, plate XIII) and the symptoms of which are a gradual drying and hardening of the tissues of the plant. This form of disease, varying much in degree, is rather prevalent in our poppy crops, and while more or less completely arresting the secretions of drug and reducing the size of capsule, we, as a rule, find a considerable proportion of well-developed seeds. It is a most obscure form of disease in as far as relates to its cause. We find it on crops, on irrigated and unirrigated lands, in dry and poor soils, as well as those which lack neither manurial condition nor moisture. It would appear to be due to a partial arrestment of the vegetative function as the plant attains the flowering period. The plants up to that period are apparently quite healthy, and the first symptoms of the disease are usually a slight persistence of the sepals, an imperfect expansion of the petals, and a more or less complete persistence of the stamens: these for many days after the fall of the petals, and indeed, until after the capsule is fully developed, still hang from its base with shriveled and somewhat elongated anthers. The capsules of such plants are always of small size, generally numerous (from 12 to 20, and even 30), ~~and~~ rarely yielding drug to more than two incisions, and this scantily. They thus often seriously deteriorate the crop, and from a small experiment I made last season from seeds of an affected plant, I find that they are only too truly reproduced from seed. Occurring, as they do, in nearly every plot of poppy, and as the Assamees take

no precautions whatever in selecting their seed, we have here another source of deterioration of crop, distinct from that which I have previously pointed out, viz., that arising from healthy and vigorous plants with a poorly developed milk-system. I can suggest no remedy whatever for the above affection or deteriorated condition of the poppy: but knowing that its seed reproduces its kind, care should be taken to eradicate such plants as they appear.

4. I may here notice two bundles of poppy sent me as affected with some form of disease by the Sub-Deputy Opium Agent of Bettiah. I had also very similarly affected specimens sent by sub-divisional officers of the Benares Agency. Mr. Shaw, in the letter accompanying the specimens, significantly enough remarks: "that it is chiefly confined to weakly plants on poor soil." A portion of an affected plant with longitudinal sections of the stem are shown under figure 2, plate XIII. The plants sent were all of slender growth; stems nearly or quite simple, from 24 to 36 inches high, and, as well as the leaves, more or less discolored. The development of the capsule has been arrested immediately after or even prior to the fall of the flower; the sepals and petals in many cases had never expanded, but withered in the bud, while the more developed capsules were all malformed, usually curving over (*vide* figure) and presenting the front of the stigmatic rays to the peduncle. I carefully examined the roots of these plants for parasitic fungi, but found none likely to cause any serious injury. The common broomrape, (*Philipœa indica*), had indeed infected several of them, and doubtless increased the other starving evils. The main or tap-root in very few instances exceeded two inches in length, and was but very slightly ramified. Sections of the stem from the neck of the plant upwards (*vide* figures *a*. *b*. and *c*.) exhibit a desiccated pith, less or more regularly broken up into horizontal chambers with intervening discs. I thought it desirable to illustrate this chambering, as not unfrequently, such specimens have been sent me, and the chambering attributed to insects operations. I may here explain that in many very vigorous specimens of poppy, from a want of correspondence in the development of the vascular and cellular tissues, we frequently find the pith less or more broken up into chambers, while the plants nevertheless continue perfectly healthy; but in such slender-stalked samples as those under observation it never does occur when the supply of sap is equal to the demand, and is thus a clear proof of unhealthy action. It is thus evident that the local failures illustrated by the above samples from Bettiah and other divisions, while aggravated by poorness of soil and imperfect root-development, are chiefly due to an inefficient supply of moisture in the soil, while the temperature was high and dry. Small and dwarfed though they were by the poor soil conditions, the failing supply of moisture alone prevented their attaining maturity. A bundle of very similarly affected specimens was also sent me by Mr. Shaw from the unirrigated portion of his division. Singularly enough, amongst these, as well as in the bundle from the irrigated lands, a considerable percentage of the plants consisted of those degenerate or wilding forms with the capsules opening by pores under the stigma. It is thus probable that the specimens in both cases had been sent from poor neglected fields, as good cultivators are careful to eradicate such wilding forms as their flowers expand. The plants were affected in various stages of development; some from six to ten inches high with no flowers set, while others were from twelve to twenty-four inches, with more or less fully developed flower-buds. I observed no broomrapes on the roots of these specimens, but the leaves, it is noteworthy, were more extensively affected with the true poppy mould than those of the specimens from the irrigated lands. In no case, however, was it sufficiently developed to have caused any serious injury to the plant; their arrested growth, and more or less, aborted flowers, as in the former instance, I wholly attribute to a failing supply of moisture, this very probably having been aggravated by drought and high temperature.

5. *Sun-burning*.—The "Moorka" or "Joorka" of the natives. Samples of plants thus injured have been sent me from several districts; and in the younger stages of development, we frequently observe them thus injured in the

field (*vide* figure 3 plate XIII). The leaves are dry and withered, with more or less discolored purply-black or brownish veins, while a longitudinal section of the stem shows a dry and shriveled apex, and the pith decaying from above downwards. This, as I have above remarked, is simply due to *sun-scorching*; plants frequently exhibit those symptoms, both in poor and rich soils, when the weather is hot and a deficiency of moisture in the soil to enable the roots to keep pace with the leaf transpiration. We also frequently observe that lateral shoots have broken out from plants thus affected when water has been supplied before desiccation had proceeded too far.

6. *Root-Canker.*—In stiff clayey soils, with an excess of the oxides of iron or manganese, poppy is frequently very seriously affected with root-canker; we also find a tendency to that disease in nearly all soils containing an excess of any of the alkaline salts. In some cases, I have found the tap-root completely corroded to a little below the neck of the plant, presenting an abruptly truncate appearance and frequently forming a less or more enlarged *callus* (as the extension of the cellular tissue is then called) from which sprung tufts of usually abortive rootlets. In such, the leaves gradually wither from below upwards, and all ultimately assume a pale brownish yellow color with darker colored veins. The leaves individually decay from the apex and circumference to the base, so that while the central parts are fresh and green the margins are quite withered. The younger leaves and terminal bud are the last to dry up, which they do when they have exhausted all the sap in the pith. During the process we generally observe the lower surface of the leaves more or less speckled with resinous exudations. Young crops of poppy frequently suffer much in clayey and saline soils from a root injury much akin to the preceding, though we can scarcely term it canker. In this case the main root is abruptly reduced (as if by an escharotic application) immediately below the surface of the soil, to a mere cord, from two to six lines long (*vide* figure 4, plate XIII) and then, in an equally abrupt manner, expanding to its normal size and presenting quite a fresh and healthy appearance to its extreme point. This, of course, at once seriously checks the growth of the plant and indeed kills all the less vigorous; the more robust gradually form a *callus* over the injured part and produce rootlets from its upper and lower surface, thus partially recovering but rarely ever acquiring any great vigour. As it appears to me this injury is in many cases wholly due to the abrasion of the softer tissues in a dry and baked soil; it may be either by natural shrinkage of the soil, or from the crops having been irrigated in windy weather, thus giving the young plants play at the neck: the soil hardening and wind prevailing, the softer and exposed portion of the root would thus be more or less regularly abraded. In other cases, however, I have observed very similar effects on light open soils containing an excess of saline matter. This, in dry weather, formed an effloresence on the surface of the soil, and corroded the softer root tissues with which it came in contact. For the latter evil, of course, means must be adopted for reducing or neutralising the excess of saline matter: while, in the other case, or when plants suffer from the shrinkage of strong, clayey soils, I would strongly recommend the culture of the poppy on ridges as previously explained.

7. *Petechia*, (Italian *petechio*, a flea-bite.)—An affection by which the skin is covered with specks or spots, somewhat resembling those caused by the bite of the above insect. The term is thus quite applicable to a disease not unfrequently affecting poppy (*vide* figures 1 and 2, plate XII of the upper and under surface of an affected leaf). The first sign of the disease is shown by the leaves, acquiring a pale yellowish tinge, and subsequently the whole surface is gradually studded with specks and patches of a pale purply-black color; the coloring matter spreads, and ultimately more or less of the upper cuticle of the leaf acquires the above tinge. As shown in the sketches of an affected leaf, the disease, though distinctly enough marked, is much less developed in the lower than the upper surface, which, in the advanced stage, is indistinguishable from *purpura*—literally the purple or livid disease. The discoloration is chiefly confined to the leaves, and is rarely accompanied with any external exudations from the tissues. In many cases this disease arises

from the overcrowding of plants in low and damp soils, and generally it is due to excess of water in the soil causing a gorging of the tissues and rupture of the finer vessels of the leaves; the peculiar color assumed is of course due to the oxygenation of the escaped sap. Plants thus affected, may bear flowers and even perfect seeds, but as might be anticipated they rarely yield much drug. The fact of their perfecting seed however, and this being indiscriminately collected with that from unaffected plants tends to extend the disease, and explains its occurrence under the most favorable cultural conditions, on the principle that affected plants have a great tendency to transmit it to their offspring.

8. In a report on the modes of improving the cultivation &c., of poppy, I had occasion to refer to the blighted crops of 1871. I suggested that the injury was probably wholly due to the then prevailing low temperature and excess of moisture: that under such conditions transpiration from the leaves would be greatly suppressed, and the tissues become gorged with fluids and induce a general morbid condition. While moist and cloudy weather continued, crops thus affected might exhibit no marked symptoms to a casual observer, but with the breaking up of the clouds and the appearance of the sun, there would be a demand for sap which the plant could not supply, and thus, as if by some sudden blighting influence, they would be less or more discolored, droop and wither. To illustrate the effects of such conditions on the poppy plant, I had a few plants closely covered up and the soil (in which they grew) daily saturated with water. I kept them thus for some seven or eight days (soil and surrounding atmosphere alike saturated), and then suddenly exposed them to the sun; the result is shown by the specimen figured plate XI. It will be observed that while the main root is apparently quite fresh, the stem has acquired a purply-black hue, the leaves brown and withered (having in the first instance drooped more or less), the more advanced flower buds imperfectly expanded, while the younger are wholly arrested. The plants died without producing any drug or good seeds. After a re-perusal of the reports of the sub-divisional officers, I am more and more convinced that the so-called blight of 1871 was really of this nature: variously modified in different localities, by soil, temperature, and degree of moisture.

9. *Injuries caused by parasitic fungi.*—These are fortunately not numerous, and the most serious perhaps are those caused by the poppy mould, *Peronospora arborescens.* I first observed living specimens of this mould on the opium poppy in the Chota-Nagpore district in January 1873. I observed it not on any of the plants during that season in my experimental gardens, nor, with the exception of the above, did I find any trace of it in any of the divisions of the Behar Agency which I visited. In March 1873, Dr. Henderson reported its occurrence in a field in the Beheea district, Shahabad division. I had examined this field with the Sub-Deputy Opium Agent on the preceding month; found no trace of mould on the leaves, and had grounds for concluding that the failing of the plant was wholly due to poverty of soil. As confirming this, it was noteworthy that the patches of plant (on the spots where the little manure that the field had got was heaped) were in full vigour, whereas all the others were simply starved and dwarfed. Again, in February 1873, I had a second opportunity of examining *mould-affected* plants in samples sent me from the sub-divisions of Jalaoun, Mynpoorie and Etwah. The mould, as it appeared to me then, had caused very serious injury to some of these plants, but, from subsequent observations, I am now convinced that they had primarily suffered from drought. During the past season I have carefully observed the development and extension of the mould which affected, very extensively indeed, several of my experimental plots, and from what I have seen of it, I do not think that it is at all likely to prove anything like as destructive to the poppy as its ally, *Peronospora infestans,* to the potatoe: the less succulent structure of the poppy is evidently unfavorable to any rapid or general extension of the mycelium, and out of the many thousands of poppy which I have now seen less or more infected with the *mould,* I have seen none fairly succumb to it:

all have flowered, yielded drug—*I am, indeed, not prepared to say in undiminished quantity*—and borne seeds. My last season's observations, which I will now record, tend to show that *Peronospora arborescens* is never at all likely to deteriorate to any serious degree our poppy crops. On the most advanced plants of the Deegah garden, poppy mould was first observed on the 18th December. It was confined to the lower and matured leaves, and only observed on a very few plants. It gradually, however, became more and more general, and by the first week in January, it had broken out on all the more advanced crops, but, as in the previous instance, in *all cases confined to the matured leaves:* none of the upper and developing leaves had a speck of it. I tried numerous applications to the affected plants and was under the mistaken impression that some of these had quite a magical effect in arresting the mould. This was the case with some plots of plant which had been dusted partly with sulphur and charcoal, as also with several of the alkaline and earthy salts, *with* and *without* charcoal. The effects altogether appeared most satisfactory. The mixtures were applied on the 10th of January, and on the 12th we had a fall of 0·24 of an inch of rain. The results were striking. In a few days, plants with only the upper and immature leaves unaffected with mould completely renewed their vigour, while the development of the latter seemed quite arrested, none of the younger growths showing a trace of it. Prior to my having seen the apparently preventive effects of these mixtures, however, I had been so alarmed with the general diffusion of the mould that after enabling my sirdars to distinguish *mould-affected* from *naturally decaying leaves*, I had the whole of the establishment engaged in plucking off and carrying to the rubbish heap all infected leaves. I had thus the crops from six beeghas gone over, and had nearly the whole of the lower leaves (which alone were infected) taken from the plants. I of course adopted these measures with a view to prevent as much as possible the further diffusion of the mould from these spore-teeming leaves. This, I found, was useless work, at least in as far as related to the existing crop: it is likely, however, to have served a purpose in lessening the number of spores which await the crops of the following, if not subsequent seasons; for it is difficult to say how long such vitalised germs may sustain a dormant existence. From the 12th to the 26th of January the *mould* made no progress whatever: the upper and lower series of cauline leaves showed scarcely a trace of the mould. The extraction of drug had now commenced from the more advanced crops, and the leaves which I include in the lower cauline series were of course fully matured. As I have particularly in view the illustration of the periodical development and extension of the poppy-mould, I shall here more particularly define the corresponding stages in the development of the poppy, thus: the *first* stage extends from the unfolding of the first plumulary leaves to the completion of the series forming the radical tuft; the *second* stage extends from the unfolding of a distinct stem to the formation of the nascent flower-bud; the third stage comprises the unfolding of the upper cauline series of leaves and the development of the flower-bud; while the fourth and last stage, is the expansion of the flower, the development and maturation of the fruit. Now, it will be seen from observations detailed below, that the development and extension of the mould, are successively limited to the several periods in the development of the poppy as I have defined them. In the first invasion of the mould the whole of the radical leaves were infected, some twelve days later the mould appeared on the lower cauline leaves, and in a few days the whole of the upper leaves of this series were almost simultaneously invaded *vide* plates VIII and IX of the Behar and Malwa poppy, in which it will be seen, while the upper cauline series of leaves is unaffected by mould, those of the lower series (of which I have introduced a few of the uppermost only in the figures) are extensively invaded: the discolored patches being the parts affected with the mould. We pass on to the third stage, in which the mould invades the whole of the upper cauline series, after having passed another period of dormancy of about fourteen days (*i. e.*, from about the 30th of January to the 12th of February. The plant shown on plate VII is a very fair representation of its peculiar distribution) being at first quite local,

breaking out in insulated specks, gradually extending and amalgamating with others, until the whole leaf surface is less or more invaded. This rarely occurs in the Behar poppy, the extension of the mould being checked and retarded by the primary and secondary veins (*vide* figure 1, plate XIV, for an enlarged view of a portion of the leaf). In the Malwa varieties of poppy, on the other hand, we find very frequently the whole surface of the leaf invaded and destroyed: the thin, almost membranaceous, texture of the leaves, and the finer veining affording a more easily permeable matrix. Thus even the uninvaded portions of the leaf soon become dry and brown, while in the case of the coarser textured poppy of Behar, the green hue of the uninvaded parts is often retained for weeks, or until its natural decay. It is important to observe that the mould does *not* necessarily continue to extend, wherever a green matrix presents itself. This, as it appears to me, is a clear proof that atmospheric influences have little to do with the extension of the poppy mould (and this I shall subsequently support by other observations) but that on the other hand it is dependent on the degree of maturation of the matrix: the chemical changes effected at a particular period being alone favorable to the development of the mould. This is a point of great importance. Hitherto it has been customary to correlate the sudden appearance and rapid extension with peculiar conditions of atmosphere. Now, as regards all terrestrial fungi there can be no question as to the influence of atmospherical conditions in promoting or otherwise, their growth: I do think, however, that careful observations will find this less marked in parasitic species limited more or less to the decaying parts of particular plants, while in the case of those affecting only the living organs of plants and specifically limited, I am inclined to believe that their development and extension is largely, if not wholly, dependent on their fosterers: that at most the atmosphere can but indirectly promote their growth. In the case of the poppy mould, for example, why, on the assumption that it is dependent on particular conditions of the atmosphere, should we thus find its extension periodically limited by the several stages of development of its fosterer? and again, why, if the atmospheric theory be correct, is the extension of the mould on the leaf so peculiarly localised (as I have shown it to be) and much of the green matrix wholly uninvaded?

10. Prevalent though the mould was on the leaves of the poppy (an idea of which may be formed by a reference to the figure) I really, after very careful observation, cannot say that it in any marked degree reduced the flow of drug. Plants even more seriously parasitised than that illustrated yielded quite as copiously as others un—(or scarcely at all)—affected. I should not be surprised, indeed I anticipate, that the analysis of the opium from the more extensively parasitised plots will afford more marked results, and that possibly in having a paucity of alkaloids. The abnormal extraction of carbon in one form or other from the poppy by the mould, will almost to a certainty reduce the percentage of both *morphine* and *narcotine* as being their *principle* or *basic* component.

11. I should here add that I was particularly observant of variations in the color of flowers in the poppy as possibly presenting less or more immunity from the mould. This, it is well known, is the case with many varieties of cultivated plants. In the common Larkspurs (*Delphinium consolida*), *e.g.*, I have observed in the Botanic Gardens, Calcutta, that the blue-flowered varieties were much more liable to be infected and destroyed by a parasitic fungi (*Sporotrichum* sp. which infected and reduced to a dry film the cuticle of the root) than either the white or red-flowered varieties. It is worth while quoting a few of the cases noticed by Mr. Darwin in illustration of the correlation between color and immunity from certain diseases. "Thus, in the United States purple-fruited plums of many kinds are much less affected by a certain disease than green or yellow-fruited varieties. In the Mauritius, red sugar-canes are much less affected by a particular disease than the white canes." On the other hand, I may add that in India the red cane is much more subject to disease than the white. Red wheats are believed to be hardier than white; in America,

I learn that some of the red wheats are also less liable to the attacks of the terrible devastators the Hessian Fly and wheat midge (*Cecidomyia destructor* and *trilici*) as well as rust and other fungoid affections. Again, in India (the North-West Provinces) on the other hand, the *red* varieties are said to be much more subject to *rust* than the white kinds. As regards the varieties of poppy, however, I have failed to detect any co-relation between the color of the flowers and immunity from the mould, and as regards color of stem, the *kalodantie*, or black-stalked poppy, is as liable to infection as the ordinary green-stalked varieties. I have observed, however, that the *kutylea*, *i.e.*, the cut or *thistle-leaved* variety, is really less liable to be infected with the mould than the ordinary and more entire leaved varieties. This is no doubt in part due to the thicker and firmer texture of the leaves of the former variety, which thus offer greater resistance to the invasions of the mould; the fact also that, as compared with the other varieties, there are scarcely more than half the number of *stomata* in a square inch, may check the development of the mould.

12. The following remarks on the condition of the weather for the week preceding and following each of the periodical invasions of the poppy mould fully support the view I have taken. Thus, in the last week of December, with a maximum temperature in the shade of 80° and a minimum of 44°; the mean of the dry and wet bulbs during the night was 0·64, and during the day 10°41, and the prevailing winds south-by-west. Again, in the first-twelve days of January the maximum temperature was 77° and the minimum 38°; the mean of the dry and wet bulbs during the night 1°83, to 10°73 during the day, while the prevailing wind was still south-by-west. Now, with a considerably *drier* temperature than in the last week of December, while the mould was quite dormant, we have it in full activity from about the 6th to the 12th instant, the winds continuing much the same throughout. On the 12th instant we had a fall of the 0·24 of an inch of rain, which in no way stimulated (as I indeed then feared it would) the mould, on the contrary, from that day it ceased in a great measure its extension, and the crops, renewing their vigour, produced healthy leaf-bearing shoots. This preceded another period of utter dormancy on the part of the mould, and which as we have seen was continued to about the 26th instant, say 14 days; the maximum temperature of which was 79°5, minimum 33°0, nightly mean of dry and wet bulbs 0°78, daily mean 11°86, the prevailing winds south-by-west. On the 24th instant we had a very light shower of rain, and the weather continued cloudy: not, however, until the 26th instant did the mould again exhibit any activity; from that date, however, up to the 30th or so, it extended rapidly over the first series of cauline leaves, breaking out first along their margins and later on their central parts. Now, from the 27th to the 30th, we had a maximum temperature of 84°0, a minimum of 41°0, nightly mean of dry and wet bulbs 0·77; daily mean 14°77; the prevailing winds west by south-west; thus really affording no tangible change in the atmospherical conditions, though including periods of high activity and utter dormancy on the part of the poppy mould. We now pass to the last stage of the mould's history. From about the end of January to the 12th of February the mould was again quite dormant, during which period the maximum temperature was 82°; the minimum 39°5; the nightly mean of dry and wet bulbs 1°87, daily mean 10°96; rainfall 0·37 of an inch, prevailing winds west by south-west. Again, from the 12th to the 18th of February, during which period the mould broke out over the whole of the upper cauline series of leaves, the maximum temperature was 84·0, the minimum 39°0; nightly mean of dry and wet bulbs 3·66, daily mean 18·78; prevailing winds, west by south-west. Thus with an increasingly high and dry temperature the mould had again a limited period of activity. After very careful observations I have thus altogether failed to detect any definite relations between the conditions of the weather and the appearance and extension of the mould.

13. I shall now detail the results of a few observations and experiments which appear to me to throw considerable light on the conditions favorable or otherwise to the development and extension of the mould. I have frequently

remarked that while poppy less or more under the shade of trees was nearly or quite free from the mould, the plants in the open were less or more extensively infected. On a little reflection it very naturally occurred to me that there might be some relation between the fixing of *carbon* in the plant and the development of the mould. Now, we all know that the formation of carbon is largely dependent on the direct action of the sun's rays; that the more a plant is exposed to the influence of light there will be a proportionate increase in the quantity of carbon fixed in the tissues. I have not lost sight of this possible relation between the fixing of carbon under the action of the sun's rays and the development of the mould. The most casual observer would have been struck with the difference of the plants under the shade of the trees and those fully exposed to the sun. Under shade, as the plants matured, the leaves acquired an almost uniform strawy-yellow tint(*vide* figure 3, plate XII), while the exposed plants were all more or less splashed and spotted with various shades of brown from the invasion of the poppy mould. Again, in a few *variegated plants* which occurred amongst the crops, I observed while the green portions of the leaf were all more or less affected with the mould, it had nowhere invaded the variegated portions (*vide* figure 2, plate XII). The non-invasion of the *white* portions of the leaves by the mould may be explained by the fact, that while in the *green parts* of plants a less or more continuous process of decarbonation (*i.e.*, a fixing of carbon in the tissues and an elimination of oxygen) is going on, while the *white parts* of plants, on the other hand, exhale carbonic acid, being unable to deoxydate it and fix the carbon; as compared with the green parts their functions are thus quite antagonistic. The mould immunity of the *white portions* of plants may thus (as in the case of plants under shade) be simply due to a deficiency of carbon in the tissues. It may also, of course, be in part due to the formation of some peculiar principle unfavorable to the development of the mould (*e.g.*, etiolated leguminous plants produce *asparagin or malamide*) and not simply to defective decarbonization. I have yet another somewhat analogous case. One of the broomrapes (*Phelipea indica*) is in many districts a serious pest to the poppy. It is very prevalent in parts of the Patna division, and I have had many opportunities of observing it on the poppy. I have only to do with it here, however, as indirectly affecting the extension of the poppy mould. I should first explain, however, that experiments have shown that in every stage of development all brown parasites (of which *Phelipea indica* is one) whether exposed to the full action of the sun's rays, or in the shade, or even darkness, they absorb oxygen and give out carbonic acid, as in the case of etiolated plants, &c. I carefully observed and compared poppy plants infected with the broomrape, with others not infected, and in every case, I observed where the broomrape had fixed itself on the taproot of the plant, the mould had developed itself but slightly on the leaves, and this chiefly along their margins (*vide* plate XV). Reflecting then on these several illustrations; (*first*, the comparative immunity of poppy plants from the mould under the shade of trees; *secondly*, of the white portions of variegated plants; and *thirdly* of plants infested with broomrapes), I am fully justified in concluding that the development and extension, indeed, I am almost inclined to say existence, of the poppy mould is dependent on the function of decarbonization. This much my observations have shown, but unfortunately each of the above conditions of immunity involves, as I think, a more serious deterioration of the drug-secreting quality of the poppy then would even an extensive invasion of the mould; I confess that I see no probability whatever of attaining the real object in view, *i.e.*, suppressing the mould, while sustaining and promoting the drug-secreting powers of the plant. I may here casually remark that the above observations on the periodical development, &c., of the mould, may throw some new light on the devastations of its ally, *Peronospora infestans*, on the potatoe, though I am afraid that in this instance also, it will rather have a theoretical than a practical interest. I need not here relate the several experiments I made (*e.g.* impregnating water with *ammonia, carbonic acid*, &c., and applying it to the plant, as also subjecting them to air mixed with various gases) by way of showing in how far the above views could thus be independently substantiated;

the results are really of no practical value, and to give them a theoretic or scientific interest, I must work them out more fully than I have yet had time to do.

14. It is generally assumed that the diffusion of this and cognate moulds is effected by the spores which teem on the mature plants, and this is no doubt the case in so far as relates to the annual re-appearance of the mould, but I think it is a mistake as applied to any particular season. If the diffusion was thus by the successive spore-fruits, we would naturally expect to find the plants variously affected; for example, while some leaves had been thickly dusted with spores, and thus fairly overrun with the mould, others would have received them less, or more sparingly, or not at all. Again, according to this view, we should have had cases in which the mould had affected the upper leaves only, or *vice versâ*. We do not find this to be the case, the lower series of leaves, as I have shown, being invariably first and almost simultaneously invaded, thence upwards successively to the other series. In no instance have I observed plants with the upper leaves only affected, nor in affected plants have I, in any instance, observed unaffected leaves in which the upper and lower leaves of a series were affected. Moreover, after a very careful and numerous series of observations, I have utterly failed in discovering a single spore in the process of germination. Day after day I have had glycerine-coated glass slides placed to windward from the affected crops, but, though they frequently caught spores of the poppy-mould (as well as those of a few others, especially an *Ustilago* and a species of *Puccinia* which, during the past season very seriously affected the one, the ears only of *doob grass*, and the other, all parts of the common flax plant) all were in a perfectly dormant state. I failed also, after many experiments, to induce the artificial germination of the spores. Had they been other than resting spores for the season of their production, I must, in the course of those various experiments and observations, found, at least, some in a less or more advanced state of germination (this also would appear to be the case with the spores of the potato-mould; the germination of which, I believe, has never been observed). I am thus led to conclude that in no case does an affected crop form a centre of diffusion and extension to the surrounding unaffected crops; on the other hand, I believe that in all cases the infection is either by direct transmission of minute mycelial particles in the seeds, or by the invasion of the roots of the young plants by the germinative processes of the spores deposited in the soil or mixed up with the seed from the crops of preceding seasons. Thus only, as it appears to me, can we satisfactorily explain the general and equable diffusion of the mould in the leaf tissues of a plant; as also its special development and extension from below upwards. I may here assign a few reasons for assuming that in certain cases the mould is probably propagated by mycelial particles in the seeds. It has been shown that by subjecting seeds from plants affected with moulds, such for example, as bunt, rust, mildew, smut and the like, to certain alkaline steeps and subsequent washing, that they will not produce diseased crops. The *rationale* of the practice, being simply the formation of a soap with the oily coating of the spores, thereby rendering them easily washed off by water. Again, sulphate of copper is said to destroy the vegetating powers of the spores, while causing no injury to the seed. During the past season I subjected poppy-seeds from affected plants to various alkaline steeps, and afterwards placed them on a fine sieve, and thus exposed them for some time to a stream of water which must have washed off all extraneous matters: I at once sowed the seeds. Again, for the sake of comparison I retained samples of all the seeds untreated; these I sowed on the same date. The results briefly were that the mould almost simultaneously appeared on both crops, nor was it a whit less prevalent on those from the treated than the untreated seeds. It may be objected that the infection may have been by spores in the soil, to this I can only reply that the experimental lands referred to had not been under cultivation for upwards of fifty years, nor has there been for years back any poppy cultivation near it. The following casual observations also strongly supports the view of root infection. The *Argemone mexcana* here as elsewhere in India is very common. As a genus allied to the poppy, I have carefully examined it in case of its also becoming

infected with the poppy mould. Now in plants at some little distance from the poppy crops, and from which they must necessarily have caught an abundance of mould spores, I in no instance observed a trace of infection. On the other hand, in several instances I found specimens of this *Horned-poppy* which had been allowed to grow up along with the true poppy less or more affected with the mould. Now there is no reason why, by the spore theory of infection, the more distant plants should not have been equally affected with those in proximity to the poppy. On the other hand, the fact that those plants only were affected which had grown up together with the poppy, as it appears to me, justifies the view of infection by the roots.

15. The poppy mould has been the subject of reports from the late Officiating Superintendent of the Botanical Gardens, Dr. G. Henderson, and Mr. Kürz, Curator of the Herbarium. I have only lately received copies of those reports, and as I find that there is a considerable disparity of opinion between us on several points, I take this opportunity to discuss a few of the more important.

Dr. Henderson in paragraph 5 of his report to the Secretary to the Government of Bengal, dated the 22nd March 1873, and referring to an experimental plot of the opium poppy in the Botanic Gardens remarks, that "up to the beginning of February, although I was constantly on the out look for it, no disease appeared; but about that date I noticed some black and brown spots on the leaves of some of the best and most advanced plants which were then coming into flower. A microscopic examination of these spots revealed the presence of a fungus which Mr. Kürz at once identified as the *Peronospora arborescens*. For nearly a fortnight the disease did not progress much, it then rather suddenly showed here and there all over the field, and appeared to first attack the plants just at the ground level, causing the base of the stem to turn black and decay; from this part it proceeded up the stem, affecting chiefly the nodes, *i.e.*, the points where the leaves arise. I should remark that in many of these spots I could not detect the fungus, but the black appearance seemed to be owing to granular matter deposited in the cells." From the above it appears very evident to me that Dr. Henderson is confounding the effects of a real disease (*Gangrene*) with mould injury. From very extensive observation during the past season I find that mould injury is exclusively confined to the leaves. In no instance have I detected, after very careful observations, a trace of the mould on the stem. It will also be observed that he admits that the stem discolorations seemed to be owing to granular matter deposited in the cells. No such deposits as far as my observations go are ever found in the mould-invaded tissues; the cell contents being quite exhausted and the tissues rapidly undergoing oxydation, acquire a brown or blackish color. Again, in *paragraph* 7, " plants becoming affected before they were in flower usually shriveled up without flowering and rapidly died, ceasing to grow almost from the moment they become affected; those in full flower were not so quickly destroyed, but in many cases the capsules became pretty fully formed and yielded a fair amount of opium. The thing I noticed about all the affected plants was, that the stamens never fell off, but remained hanging around the top of the flower stalk just under the capsule, and in some cases the petals also remained adherent to the capsule, and this, I believe, was caused by the exudation of juice which glued them to the plants. On all the affected plants, and over all parts of them, juices exuded, forming small black specks all over the plants, and in some cases I found large black tears, as if drops of liquid opium had fallen on them." It will, I think, be evident to those who have perused my remarks and examined my illustration of *gangrened plants*, that Dr. Henderson has throughout strangely misapprehended the subject of his observations. He particularly remarks on the persistence of the stamens and petals on mould-affected plants; this is also a *peculiarity* of *gangrened plants* (*vide* figure 1, plate X). In other cases, however, it is due to a tendency in the stamens to change into carpels (*vide* figure 7, plate II), but all my observations clearly show, that the mere invasion of a plant by mould has no tendency whatever either to induce persistence of stamens

or any other parts of the flower. Again, the most extensively parasitised plants which I have yet seen, have in every instance, produced both flowers and seeds, though affected in a much earlier period of their growth than those on which Dr. Henderson's observations are founded. It may be objected that the effects of the poppy mould may be intensified in the moister climate of Bengal; my observations being confined to the opium-producing districts of Behar and Benares, which are of course very much drier. I did not overlook this. I, until lately, adopted the general belief that certain atmospherical conditions promoted the development and extension of the poppy mould. I had accordingly mould-affected plants under full exposure daily saturated with water at the roots, (for comparison with those under ordinary treatment) but this gave no appreciable stimulus to the mould. Again, I covered a small plot of affected plants; saturated the soil frequently, sustaining an atmosphere at the dew-point; the result was that in a short time the plants became quite *dropsical*, while, at the same time, the mould had really less extensively invaded the foliage than in the case of plants under ordinary cultural conditions: in fact it had scarcely extended at all from the time of their seclusion.

16. With reference to the remarks by Mr. Kürz, I need only briefly notice a few points of difference in his "*postcriptum* to the memorandum on the poppy disease in the Royal Botanic Gardens." First, Mr. Kürz, referring to a report of mine remarks, "I ascribe a good deal of Mr. Scott's inability of detecting any fungoid growth in the tissue of the diseased poppies up-country to the aridity of the district of which he occasionally complains, and which naturally would arrest the proper development of the fungus." In reply to this, it is sufficient to state that with a higher temperature and a degree of aridity which has resulted in a wide-felt famine in the poppy and other districts, I have nevertheless found the mould very extensively developed on our crops; so much is this the case that I am verily disposed to believe that *aridity* rather than *humidity* promotes its development. Again, Mr. Kürz remarks that, "as far as I can learn Mr. Scott has examined only the inner tissue of the leaves, whereas the developed mould appears only after all the cellular tissue upon which the fungus nourished itself has more or less completely vanished." I was quite aware of this, but requiring no lens or other assistance to my natural vision to detect the fertile or aerial threads of the poppy mould, I thought it sufficient to state that I had failed to detect any mycelial processes in subjecting sections of the injured and discolored tissues to the microscope. There is but one other statement in Mr. Kürz's memoranda which I need notice here, viz., "that parasitic fungi generally require for their nourishment nitrogenous compounds, hence moulds vegetate best at that period of development of a plant when its nitrogenous matters are most copious in the tissues, viz., before flowering time." In reply to this, I can only say that one of the highest authorities, Mr. Payen, finds nitrogen most plentiful in nascent organs, or in those in the first act of development, and this much I can safely say, that out of the many thousand mould-affected poppy plants which I have seen, the mould has never appeared on the younger leaves; it invariably breaks out on the lower surface of mature or fully developed leaves.

17. I have now to notice a few other parasitic fungi less or more commonly found in our poppy crops. *Dactylium roseum* (*vide* figure 1, plate VI). The pale rose colored patches of this thread mould are very common on the poppy during moist, warm weather; occurring alike on the leaves and stems, and in the interior of the capsules densely webbing the seeds. It is particularly common in capsules which have been injured by grubs. In the opium godowns, and, indeed, on opium everywhere, it seems to find a favorite *nidus*, covering the surface with its rosy web when left for any time undisturbed. The Principal Assistant to the Behar Agency, however, informs me that it does really no injury to the opium. It is thus described by the Reverend Mr. Berkeley. The *D. roseum* (*syn. Tricothecium roseum*) consists of a creeping *mycelium*, from which arise short erect threads, crowned above with a few *obovate uniseptate* spores. The mass is at first white, but at

length acquires a pale rose color, by which it is readily distinguished. The plant grows very abundantly on various objects, whether dead or living, and is sometimes highly destructive to cucumber plants, forming broad patches on the leaves and stem. It occurs also not unfrequently in closed cavities, as in nuts, to which it must have made its way from without, through the tissues. A solution of bisulphite of soda, or indeed anything which contains sulphuric acid, properly applied, may facilitate the destruction of the mould when requisite. I have never observed it cause any serious injury to the poppy plant.

18. *Trichoderma viride* (*vide* figure 2, plate VI). A minute thread mould forming roundish intertangled tufts of snowy-white threads, from which spring numerous spores of a pale greenish-yellow color. It is frequent on the base of the stem and the roots of poppy, though generally confined to diseased or injured parts.

19. *Sporotrichum* sp. (*vide* figure 3, plate VI). This mould is not unfrequent on the roots of the poppy, and in some specimens sent me by the Sub-Deputy Opium Agent of Chupra, it had apparently been the main cause of the destruction of the plants; the roots having assumed quite a dry and woody texture. (The common broomrape, *Phelipea indica*, had also infected the plants, but I have never seen it thus destroy the poppy). It appears in oblong or roundish patches of a pale yellowish-white color, the filaments forming a somewhat closely woven web; the spores numerous, minute, and sub-globose.

20. *Cladosporium herbarium* is very common on the older gummy exudations of the poppy, and also frequent on injured capsules or indeed any injured parts. "It consists," remarks Mr. Berkeley "of short brown-jointed wavy threads, which bear on their sides oblong or elliptic spores, with one or two transverse divisions. It is found in all habitable parts of the world on decaying substances, whether animal or vegetable, covering them with olive patches which, when in fruit, are shot with green."

21. *Rhizomorpha* sp. (*vide* figure 4, plate VI). The specimen here figured appears to be one of those flattened, ramified, root-like processes usually referred to the above genus, and which, I observe, Mr. Berkeley regards as particular states of such genera as *Polyporus*, *Hypoxylon*, &c. The above specimen was found under the cuticle of the root of poppies sent me as blighted by the Sub-Deputy Opium Agent of Chupra. On the same specimen I found the species of *Sporotrichum*, described above, and also *Trichoderma viride*. The two first named, or at least the *Sporotrichum* (which was frequent) had evidently been a main cause of the injury.

22. *Mucor mucedo*, (*vide* figure 5, plate VI) an extremely common blackish-colored mould causing considerable damage to the opium cakes during moist weather if their shells are at all soft. Dr. Durrant, the Principal Assistant to the Behar Agent, refers to it as the only serious cause of injury to which the cakes are liable. With regard to the cause or origin of the *black mould* he continues: "I am very much inclined to attribute it to the use of an undue proportion of impure opium in the manufacture of *lewa*; for it is a well-known fact that all adulterated opium of the kind and quality generally confiscated as unfit for use, if kept for a short time, will generate this fungus to any extent. This same fungoid growth also can be seen toperfection during the rainy season on the surface of all contraband opium classed as fourth sort, which, as a rule, is chiefly composed of foreign extracts and is kept in large wooden boxes till destroyed. The only remedy for attacked cakes is to at once strip off all the affected parts of the shell, and to replace it by a new one, well smeared with fresh lewa." It forms on the surface of opium, &c., cobwebbed masses of tubular, septate, and simple threads, bearing at their apex a globose membranous spore-case, which as well as the spores, are of a blackish color.

23. *Aregma moniliforme* (*vide* figure 6, plate VI) an apparently new species of Aregma which I have so named from the necklace-like character of its fertile threads. "The species," remarks Mr. Berkeley, "are all parasitic, growing on the different parts of phanogams, and in a few rare instances on cryptogams. The mycelia creep amongst and penetrate the cells of the mother-plant unless where they tend to repress over luxuriance. *P. graminis* which occurs in almost

every part of the world on grasses, and especially on cereals, is the common wheat mildew, one of the most formidable diseases of wheat, and one for which no remedy has been found." The necklace brand, *Aregma moniliforme*, is found in roundish tufts on the stem and leaves of the poppy, the fertile threads somewhat elongated, slender and moniliforme, with an obtuse terminal joint surmounted by from 5 to 9 septaté spores.

24. *Phelipea indica* (*vide* figure 1, plate XV). A phœnogamic root-parasite, frequently causing much damage to the poppy. I have in previous reports suggested that in all fields where this broomrape is at all prevalent that along with the poppy-seeds those of '*Raie*' or mustard should also be sown. The broomrape preferring the latter, a considerable proportion would thus be destroyed in weeding out the mustard. Again, I have observed that the native cultivators instead of pulling the broomrape up from the roots of the poppy, cut it over immediately below the surface of the soil, the result of which is to increase its tuberoid root-processes and enable it to shoot up again with renewed vigour. Unless very extensively affected with the broomrape the poppy attains its full development, but never yields the full amount of drug; and I have often observed while the central and secondary capsules of a parasitised plant would yield a fair amount of drug, these as well as the younger capsules would suddenly dry up. This I wholly attribute to the broomrape; the Assamees are also fully alive to the injury it does their crops. This, with a species of an allied genus, the *Orobanche cernua*, is common on many of the more commonly cultivated food plants, and where abundant, as they frequently are, cause much injury. The only remedies are those I have above suggested.

25. I will now conclude my report with a notice of the more destructive insect enemies of the poppy which have come under my observations, as also its protective and destructive birds.

The poppy cricket, *Acheta sp.*, often commits sad havoc on the young crops, its ravages extending in dry seasons from November to January. They carry on their depredations chiefly during the night, secreting themselves in the soil during the day. They are of difficult suppression, and will ever tend to increase in all tracts of country where there is an absence of forests to harbor their natural suppressors, insect-feeding birds. The only simple and really practical mode of lessening their ravages is to dust the young crops with a mixture of finely powdered charcoal and lime in the evening, repeating as occasion requires until the young plants have got beyond the stage of the crickets' attack.

26. The mole-cricket, *Gryllotalpa vulgaris*, so called from its burrowing like the mole, and even like it spurring out heaps of soil from its tunnels. It is often a most serious pest, cutting over with its powerful *mandibles* considerably advanced plants. Hand-picking after irrigation (they have a great dislike to water and are thus readily dislodged by it) is the only means I can suggest for keeping them in check.

27. The caterpillars of a moth (vide figure 4, plate XVI.) also prove very serious enemies to the young crops; their ravages extending from the end of November to February; broods successively appearing with every young crop. The drawings referred to above show its several stages, as caterpillar, pupa, and moth. In the pupa state we find it enclosed in a somewhat irregularly oblong cell of earth, formed at a depth of from two to six, or eight inches in the soil. I know nothing of the period it *naturally* passes in this state. Those that I kept made their final metamorphosis in about a month from the date of their seclusion. Several of the plots in the experimental gardens under me were much infected by the above caterpillar, but I found its depredations could be very effectively checked by carefully dusting the young plants in the evening with quicklime or with a mixture in about equal parts of the latter and pulverised charcoal. These caterpillars have serious natural enemies in the Indian crows and the common *myna*. Irrigation readily dislodges them from their soil haunts, and the above birds closely follow the irrigator and snatch every appearing caterpillar. It is curious to note that while a dry westerly wind prevails, the crows exclusively follow the tract of the irrigator,

whereas with a moist easterly wind, we observe them dispersed over the field, as they well know that under it the caterpillars are every where near, or on the surface.

28. Another caterpillar of the somewhat variable moth shown in figure 3, plate XVI, infects the poppy plant in its later stages of development and feeds alike on the leaves and the maturing seeds. The young caterpillars are of a nearly uniform pale green color, and they feed on the lower surface of the leaves, a habit which, with their leaf-like color, affords them considerable security from insect-feeding birds. With the maturing plants it gradually acquires a yellowish-brown tinge, and finally a dull grey with two lateral brown stripes. Under the latter colors it may be found penetrating the drug-exhausted capsules (carefully avoiding the younger capsules; the milky juice of which, as I know by experiments, has a strong narcotic influence on them, preceded by convulsive-like twitches). A single caterpillar will eat, or at least render useless, the whole seed contents of an ordinary sized capsule ere it passes into the pupa or dormant state. In the caterpillar and pupa states this insect is actively sought after by the Pied Starling, the "*ablak myna*" of the Hindoos (*Sturnopastor contra*). Affecting chiefly the lower surface of the leaves and the interior of the capsules, hand-picking appears to me to be the only mode of keeping this insect in check.

29. In dry seasons the later crops of poppy are often seriously affected with thrip—*Thrips adonidum*—and the red spider—*Acarus telarius*—the former puncturing and destroying the whole surface of the leaf, as shown in figure *c*, plate XVI (while the latter ~~while~~ piercing and imbibing the juices of the leaves covers them also with a fine but closely intertangled web, thus wholly suppressing transpiration and soon causing the destruction of the leaves. I know of no practical mode by which these insects could be kept in check in our poppy fields. The syringing and sulphurating affected plants as ordinarily resorted to the under-glass structures is simply impracticable in the field.

30. There is but one other pest to which I may be allowed to make a passing reference, this is the rose-ringed parrakeet, the Totha or Sugha of the Hindustanees. It attacks the ripe capsules of the poppy, and if much disturbed soon resorts to the plan of stealing suddenly down, cutting off the capsule with its strong bill and carrying it at once off to any adjoining tree where it may undisturbedly devour its seed contents. Generally flying in small flocks, this parrakeet, if not carefully watched, will soon seriously reduce the seed produce of a field.

31. I have now only to add that this report has extended over many more pages than I intended it to do. The variety of experiments and the nature of the observations however, left but one of two courses, viz., either to give them in full, or in part, and I only hope that the report may be found of sufficient interest to excuse me in having adopted the former.

I have the honor to be,

SIR,

Your most obedient Servant,

JOHN SCOTT.

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REPORT

ON THE

EXPERIMENTAL CULTURE OF THE OPIUM POPPY

WITH

OBSERVATIONS ON ITS DRUG-YIELDING PROPERTIES,

AND THE MORE PREVALENT AND SERIOUS FORMS OF DISEASE AND INJURY TO WHICH THE PLANT IS SUBJECT

FOR

THE SEASON ENDING 15TH APRIL 1874.

BY

JOHN SCOTT, ESQ.,

On Special Duty, Opium Department.

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